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TOWED BODY MOTION MEASURMENT SYSTEM INSTRUCTION MANUAL.(U)
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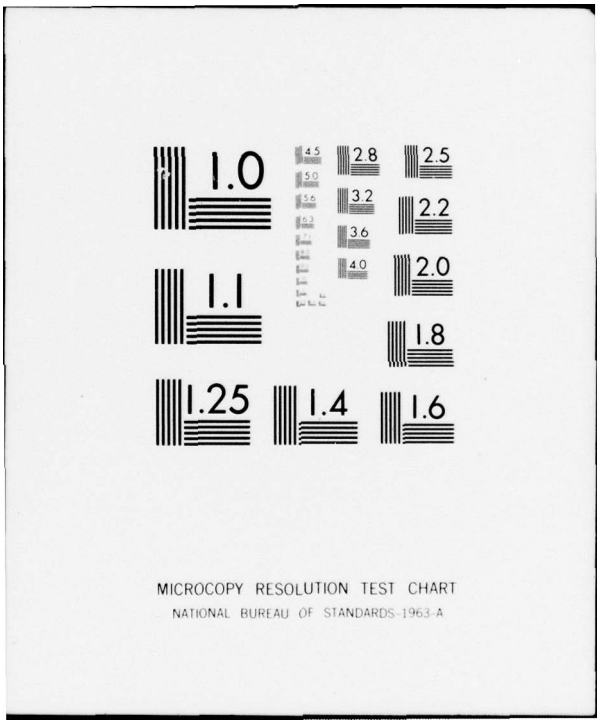
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TOWED BODY MOTION MEASUREMENT SYSTEM INSTRUCTION MANUAL

627 LOFSTRAND LANE • ROCKVILLE, MARYLAND • 301 762-7070

6500 TRACOR LANE • AUSTIN, TEXAS 78721 • 512 926-2800

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TRACOR, Inc.
627 Lofstrand Lane
Rockville, Maryland 20853

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AB

TOWED BODY MOTION MEASUREMENTS SYSTEM

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TOWED BODY MOTION MEASUREMENTS SYSTEM

I. INTRODUCTION

The purpose of this manual is to provide description and operation information of a complete instrumentation system, designed and built by TRACOR, Inc., to provide a capability to measure a number of motions of a cable towed transducer group and the tow ship. Specifications, functional and physical descriptions are given, as well as details of the installation procedure and check-out. Operating instructions are provided along with a troubleshooting and operator's maintenance section. System components are described in Appendix A, parts lists are supplied in Appendix B, and equipment photographs are shown in Appendix C.

The system was designed to obtain motional measurements on full-size equipment at sea under actual towing conditions, and to record this data continuously on magnetic tape. The system is capable of obtaining measurements of the following motions:

For the towed fish -

- pitch
- roll
- yaw rate
- vertical acceleration
- fore-aft acceleration
- transverse acceleration
- depth
- transducer-fish relative angle

- tow staff-fish relative angle
- tow cable tension

For the tow ship -

- tow cable tension
- tow cable angles
- fantail vertical acceleration
- fantail fore-aft acceleration
- fantail transverse acceleration
- roll
- pitch
- heading
- speed

All of the sensors for the above measurements are included in the system, with the exception of those for ship roll, pitch, heading and speed, which are part of existing ship equipment. Specifications of the various sensors are given in Appendia A.

The electronic portion of the system utilizes and amplitude-modulated (AM) carrier. Each sensor is excited with one of five oscillators and these various signals are added, or mixed, together for transmission and recording on seven channels of a magnetic tape recorder. An eight-channel chart recorder is used to monitor the operation of selected sensors, after the signals have been separated by bandpass filters and detected. The tape recording preserves all the data for further processing or transfer to the chart recorder.

To compensate for drifts or other changes in the electronic system, including the two recorders, a remotely controlled calibration sequence is built into the system. This calibration sequence, by use of a stepping switch, substitutes fixed

voltages for the sensor electrical output. Three separate substitutions are made for each sensor corresponding to one-tenth, five-tenths and nine-tenths full scale output of the sensor. The electronic calibration or gain check is made at the begining and end of each run at sea and, if any drift occurs, compensation can be made to correct the data obtained.

The instrumentation located in the towed fish is in waterproof containers capable of withstanding pressures of about 400 psi. These packages are connected to the tow cable for power and data transmission. The ship instrumentation packages are in suitable containers for installation in the desired locations.

Table 1 summarizes the measured quantities and types of sensors used, along with the basic sensor range corresponding to the system full scale value for each measurement.

TABLE 1

TOWED FISH MEASUREMENTS			
Measurement	Sensor	Sensor Design Range	System Full Scale
Pitch	Vertical Gyro	$\pm$ 85°	+ 45°
Roll	Vertical Gyro	$\pm$ 178°	+ 30°
Yaw Rate	Rate Gyro	$\pm$ 20 /sec	+ 20 /sec
Vertical Acceleration	Accelerometer	+ 1 /g (1)	+ 1 /g
Fore Aft Acceleration	Accelerometer	$\pm$ 1 /g	$\pm$ 1 /g
Transverse Acceleration	Accelerometer	$\pm$ 1 /g	$\pm$ 1 /g
Depth	Pressure Transducer	0 - 400 psig	0 - 300 psig
Tow Staff Angle	Potentiometer	Selected for System Tested	
Transducer - Fish	Potentiometer	Selected for System Tested	
Cable Tension	Strain Gaged Pillow Blocks	Selected for System Tested	
TOW SHIP MEASUREMENTS			
Measurements	Sensor	Sensor Design Range	System Full Scale
Cable Tension	Strain Gaged Load Cell	0-10K, 0-50K	0-10K, 0-50K
Cable Angles	Cable-Sheave-Potentiometer	---	-6 ft/rev (2)
Roll	Ship Stable Element	---	---
Pitch	Ship Stable Element	---	---
Heading	Ship Heading Gyro	---	---
Speed	Ship Speed Indicator	---	---
Fantail Vertical Acceler.			
Vertical Acceleration	Accelerometer	$\pm$ 1/g (1)	$\pm$ 1/g
Fore Aft Acceleration	Accelerometer	$\pm$ 1/g (1)	$\pm$ 1/g
Transverse Acceleration	Accelerometer	$\pm$ 1/g (1)	$\pm$ 1/g

(1) Vertical accelerometers range is $\pm$1/g reference 1/g or 0 to 2/g on absolute scale.
(2) Distances are measured to obtain cable angles.

The overall system errors are estimated to be within 1% of the full scale reading except for yaw rate which is 2%.

II. SYSTEM DESCRIPTION

A. GENERAL DESCRIPTION

A simplified block diagram of the system, figure 1, shows the location and interconnection of the major system components. Starting with the instrumentation in the fish, the Fish Instrument Package contains, in addition to a number of sensors, the electronics for excitation of the various sensors and transmission of these outputs through the tow cable to the Central Electronics Package. The sensors in the Fish Instrument Package are three orthogonal accelerometers and two gyros—one for roll and pitch, and one for yaw rate. As shown in figure 1, other fish motion sensors are connected to the Fish Instrument Package. These include sensors for measuring cable tension, tow staff angle, and fish-transducer angle and depth.

Located in the fantail area are sensors and electronics to measure motions of the ship and the tow cable. Three orthogonal accelerometers are housed in the Fantail Accelerometer Package, which also contains the electronics for the excitation of the accelerometers and tow point cable sensors; i.e., cable angles and cable tensions.

In the forward part of the ship is a Ship Motion Package that contains synchro receivers to receive the outputs of the ship heading gyro, stable element (for roll and pitch), and the ship speed indicator. The electronics for sensor excitation and signal transmission are also contained in the package.

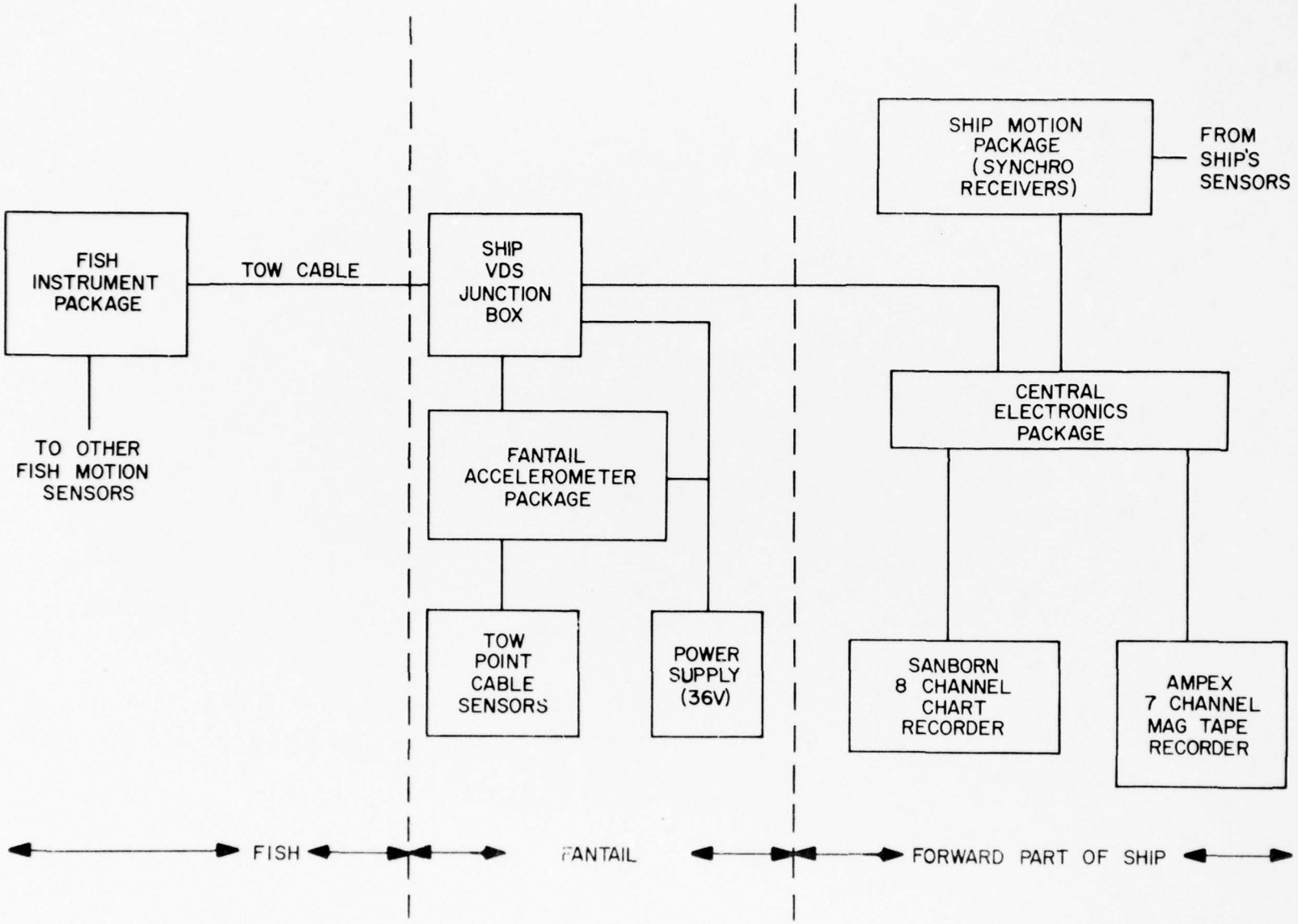


FIGURE 1 SIMPLIFIED BLOCK DIAGRAM OF SYSTEM

All the information from the various sensors via the electronic packages is fed to the Central Electronics Package where the data transmissions are converted to inputs suitable for the eight-channel chart recorder and the seven-channel magnetic tape recorder. The Central Electronics Package also contains instruments to monitor the operation of the entire system. In addition, remote control of power to the other packages is provided at the Central Electronics Package. A time mark generator is included to provide a time reference on both the magnetic tape and chart paper for synchronization.

Figure 2 traces the signal from a single sensor through the system to the recording station. This figure illustrates the use of the AM carrier system. Considering the Fish Instrument Package, a constant oscillator voltage serves as a carrier and is modulated by the behavior of the sensing device (e.g., the potentiometer output of the vertical gyro) which produces a signal voltage. This modulated signal voltage is added with two other sensor outputs (which are at different carrier frequencies) before transmission through the tow cable. Similar signals from shipboard sensors (modulated at still different frequencies) are added to the same channel by a second adder. At the output of this adder, signals from as many as five different sensors are available in a form such that they can be simultaneously recorded on a single channel of magnetic tape. For chart recording, the signals are demodulated and detected. To separate the signals, bandpass filters are used—one tuned to each carrier frequency. Each filter output is rectified and averaged, reproducing a signal proportional to the original sensor signal that then can be displayed by the paper chart recorder.

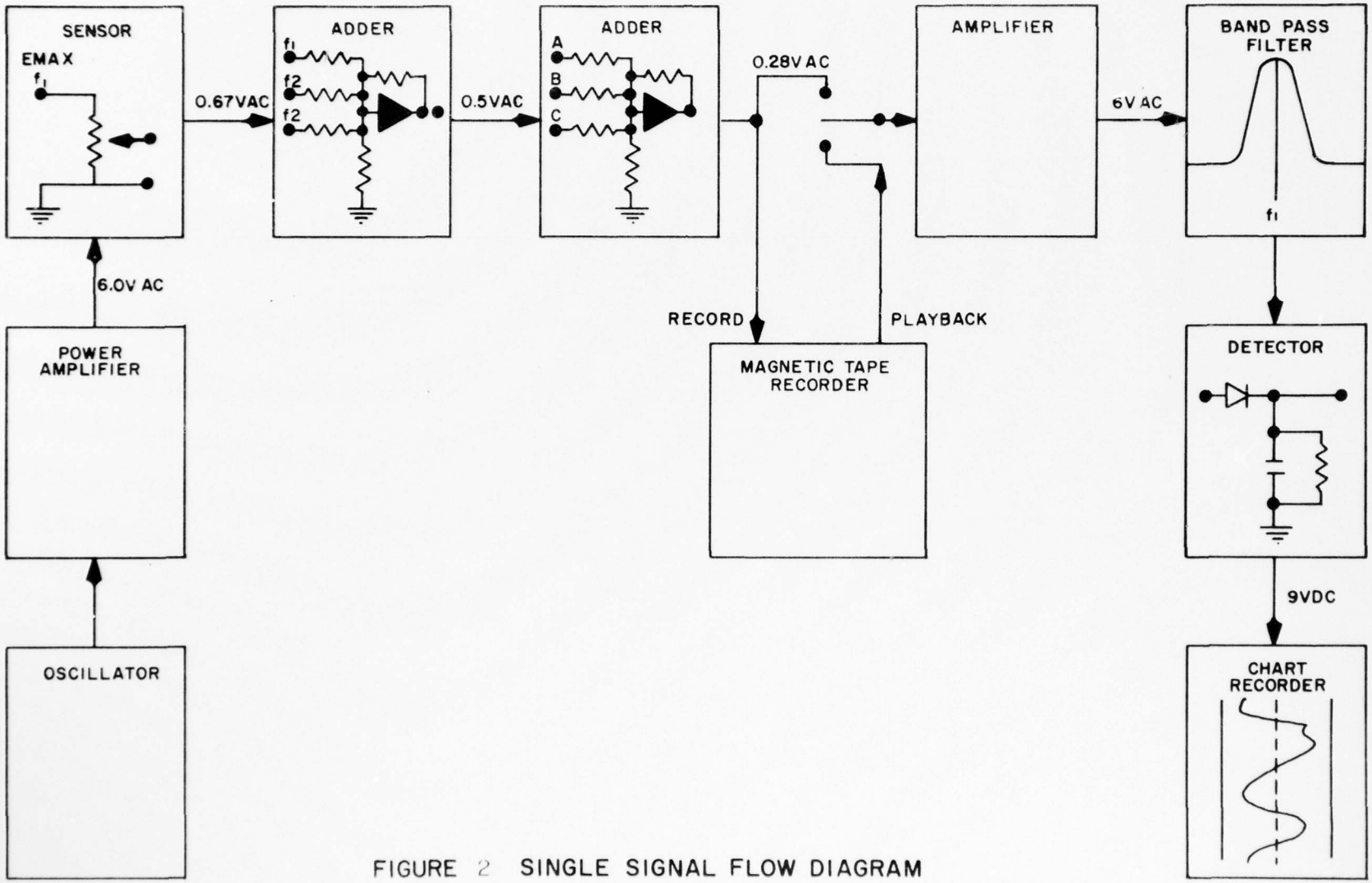


FIGURE 2 SINGLE SIGNAL FLOW DIAGRAM

A signal can also be traced through the system in terms of voltage levels. The amplified oscillator voltage of a nominal 6 vac is the excitation voltage; the smallest full scale signal from a sensor is 0.67 vac. Thus, 0.67 vac is selected as a maximum input to a fish adder. In order for the gain of all adders to be the same, each sensor signal is attenuated to a 0.67 vac maximum level by a voltage divider network. Each adder has a gain of 0.75; consequently, full scale fish adder output for one signal is approximately 0.5 vac (0.67 x 0.75). It should be noted that, since occasionally the peaks of all the signal sine waves occur simultaneously, the adder amplifier has to be capable of handling a peak voltage equal to the sum of the peak voltages of the signals.

Full scale for each input to a shipboard adder is 0.50 vac; full scale shipboard adder output is 0.28 vac. This voltage level is recorded by the FM tape recorder, which is designed to operate at a nominal 1 vac input level. The full scale voltages of the shipboard adder outputs are selected on the basis of the recorder capability. Bipolar sensor output signals are normally at half scale when no activity is occurring. It is very seldom that all signals are simultaneously at a maximum value; thus, a full scale single signal voltage of 0.28 vac is selected for input to the recorder. Since signals of five different frequencies are possible in each recorder channel, occasional clipping could occur if all signals became full scale at the same time.

Power for all electronics is supplied by power supplies operated from the ship's 115 vac 60 c/s supply. A 36 vdc supply provides power for the Fantail Electronics and the Fish Electronics Packages. The voltage is regulated to 24 vdc in the fish. A separate 28 vdc supply is used for the Central Electronics and Ship Motion Electronics Packages.

B. PACKAGE DETAILS

This section describes the four electronics packages along with their associated sensors and interconnections. For specifications and details of specific components, both those purchased and those manufactured by TRACOR, refer to Appendix A. References to this section are made by A followed by the paragraph number.

1. Fish Instrument Package and Associated Sensors (Figure 3)

The Fish Instrument Package contains electronics and several sensors located in a main instrument container (A-10) that is installed in the fish. Included are three Solid State Electronics oscillators (A-1): 560 c/s, 730 c/s and 960 c/s. Each oscillator is followed by a power amplifier (A-2) adjusted for 6.0 vac signal output level with the system in operation. Five sensors are mounted in the main container: three accelerometers and two gyros. Five other associated sensors external to this main container are depth, tow staff angle, transducer relative angle, and two pillow block strains. An excitation signal is applied to each sensor, and the action of the sensors amplitude-modulate the signal with an action similar to that of a potentiometer. The roll portion of the vertical gyro (A-16), the yaw rate gyro (A-15), the depth potentiometer (A-12), and the staff angle sensor (A-7), modulate the 560 c/s signal. The 730 c/s signal is modulated by each of the three orthogonally mounted accelerometers (A-14): vertical, fore and aft, and transverse — and by one component of the pillow block strain assembly. The remaining three fish sensors — the pitch portion of the vertical gyro (A-16), the sonar transducer relative motion sensor (A-7), and another component of the pillow block strain gage assembly — modulate the 960 c/s signal. (A 5 g

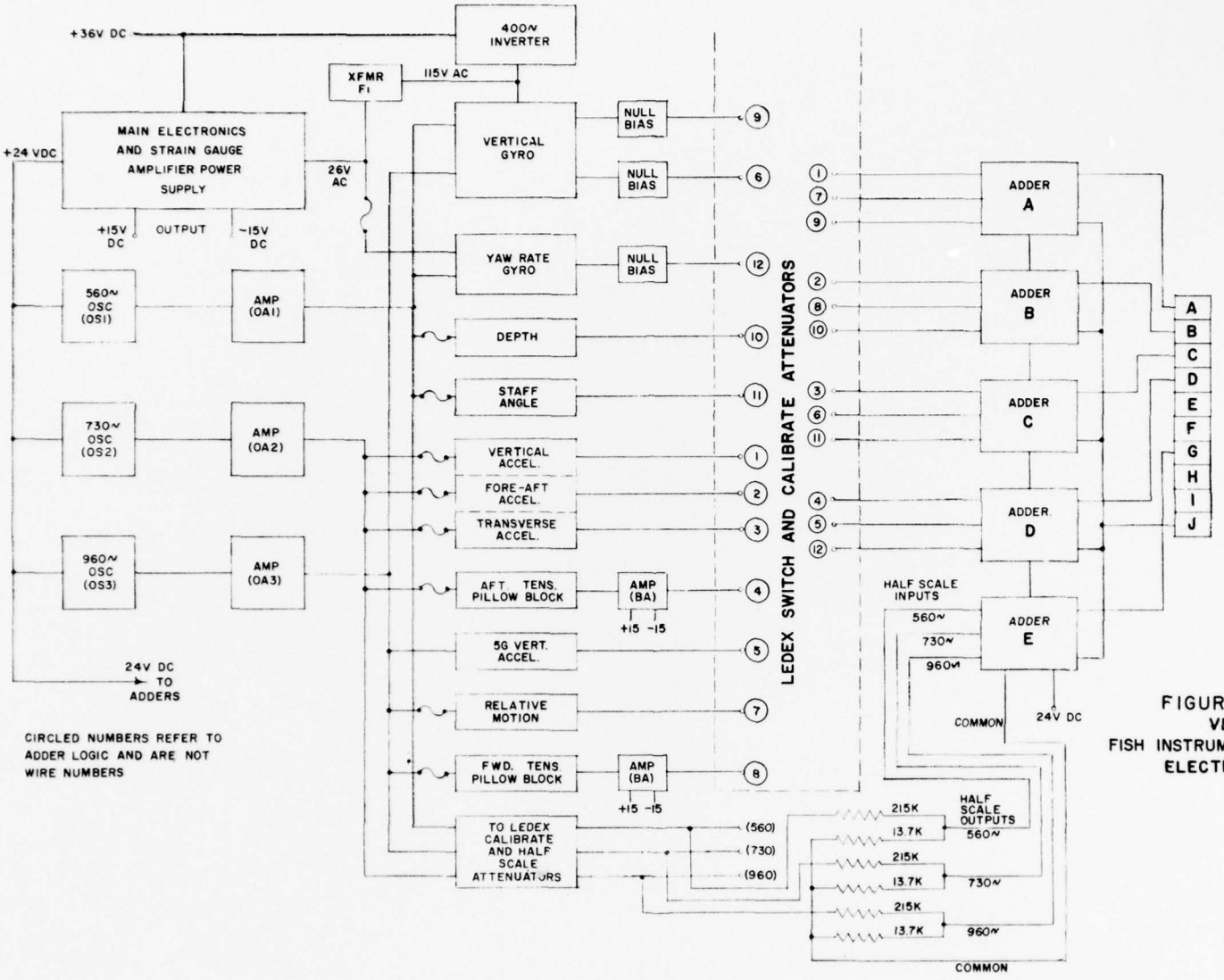


FIGURE 3
VDS
FISH INSTRUMENTS PACKAGE
ELECTRONICS

vertical accelerometer (A-14), also modulating the 960 c/s signal, is an optional sensor).

The vertical gyro roll and pitch outputs and yaw rate gyro output require a null bias circuit (A-3) to shift the zero null point out of the normal operating region. Since the pillow block tension measurements are obtained by strain gages, they are amplified with minimum loading. To accomplish this, Burr Brown differential dc amplifiers (A-11) are used. All outputs are then routed through resistive dividers which provide attentuation to make all signal levels the same and a Ledex stepping switch, both of which are located in the Fish Package. One sensor signal of each of the three fish carrier frequencies is then connected into each of four adders (A-4). A fifth adder receives signals from each oscillator after they have been attenuated to half of the full scale adder input value. These signals provide a constant amplitude monitor for reference. The VDS cable is driven by the low impedance outputs of the Fish Package adders and is terminated in the high impedance inputs of the shipboard adders, minimizing cable losses.

To provide a system check, the Ledex switch has three "calibrate" positions in which a nine-tenth, five-tenth, or one-tenth full scale signal is substituted for the sensors signals to the adder.

Several types and values of power are required for the Fish Instrument Package (figure 4). Power for the fish electronics originates in the 36 vdc supply (A-18) located in the ship's ram room. Power is carried to the fish through paralleled wires to minimize loss. A two-section RC network serves as a low pass filter and decoupler at the fish. The supply

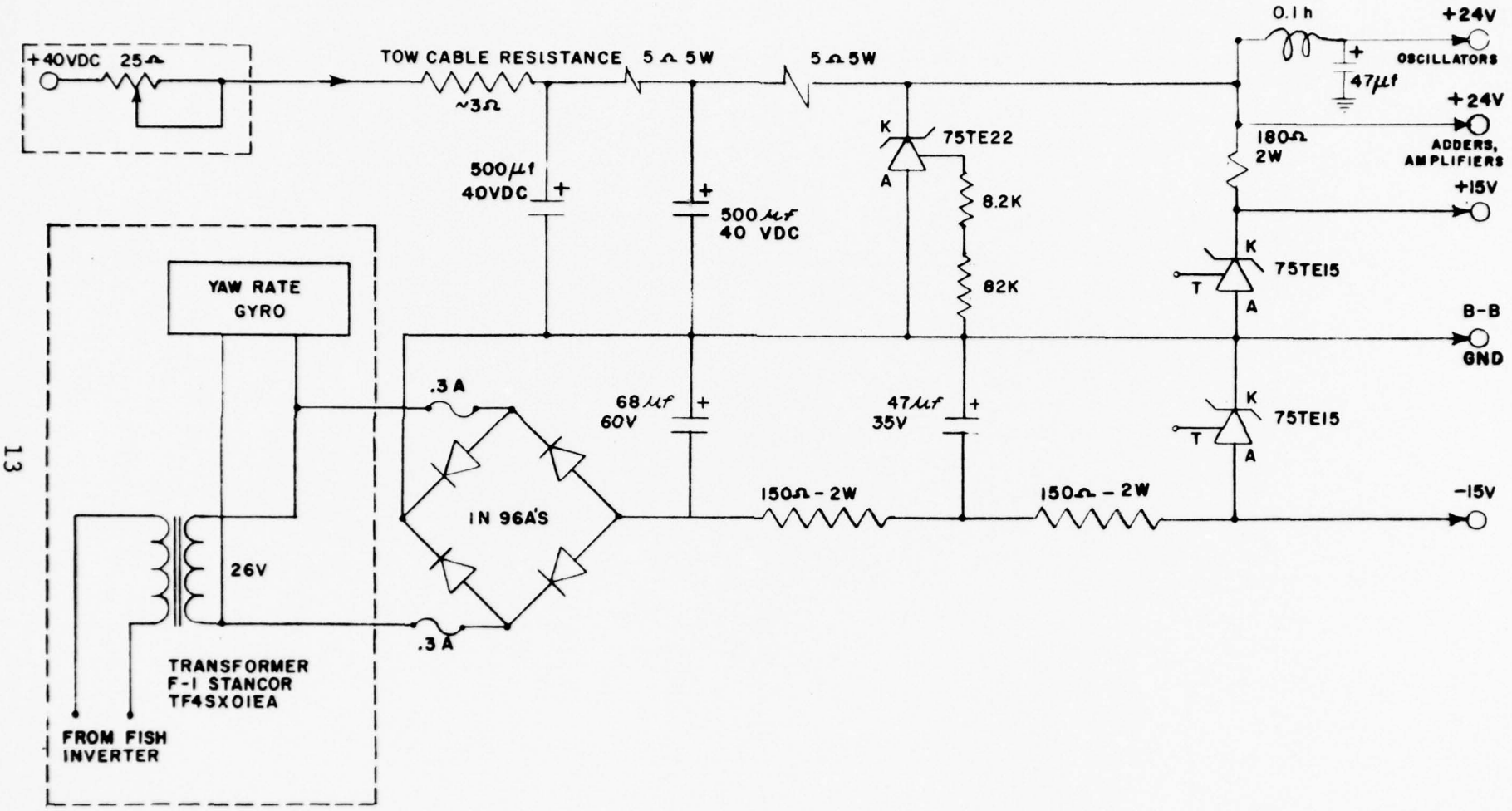


FIGURE 4
MAIN ELECTRONICS AND STRAIN GAUGE
AMPLIFIER POWER SUPPLY
FISH PACKAGE

is then regulated to +24 vdc for the amplifiers, adders and oscillators by the zener action of a Super-Reg (A-19). Additional filtering and another Super-Reg provides a +15 vdc supply for the Burr Brown differential amplifiers (A-11) used to amplify the strain gage outputs. The 115 vac 400 c/s power required by the vertical gyro is provided by a 400 c/s inverter (A-20), which is driven by the +36 vdc power supply located in the fantail. A hermetically sealed transformer steps down the voltage to 26 vac, which is rectified by a bridge diode circuit, filtered and regulated by a Super-Reg to provide a -15 vdc supply for the Burr Brown amplifiers. A capacitor network is used in the 26 vac, 400 c/s supply to create a three-phase supply for the yaw rate gyro. A small fan is also operated from the 26 vac supply to provide circulation and prevent hot spots from developing in the package.

2. Fantail Accelerometer Package and Associated Sensors (Figure 5).

The Fantail Accelerometer Package contains three orthogonally mounted accelerometers (A-14), a 1300 c/s oscillator (A-1), an oscillator amplifier (A-2), a differential amplifier (A-11), impedance matching amplifiers (A-4), and power regulation circuits. Three sensors for tow point cable angles and tension are external to the package.

The six sensors amplitude-modulate the 1300 c/s oscillator signal as in the Fish Instrument Package. As with the strain gages in the fish, a Burr Brown differential amplifier (A-11) is used to prevent loading and to amplify the tow cable tension strain gage signal. Each sensor output is then connected to an impedance matching amplifier that drives cable 1FT with a low impedance output, providing low loss and low crosstalk.

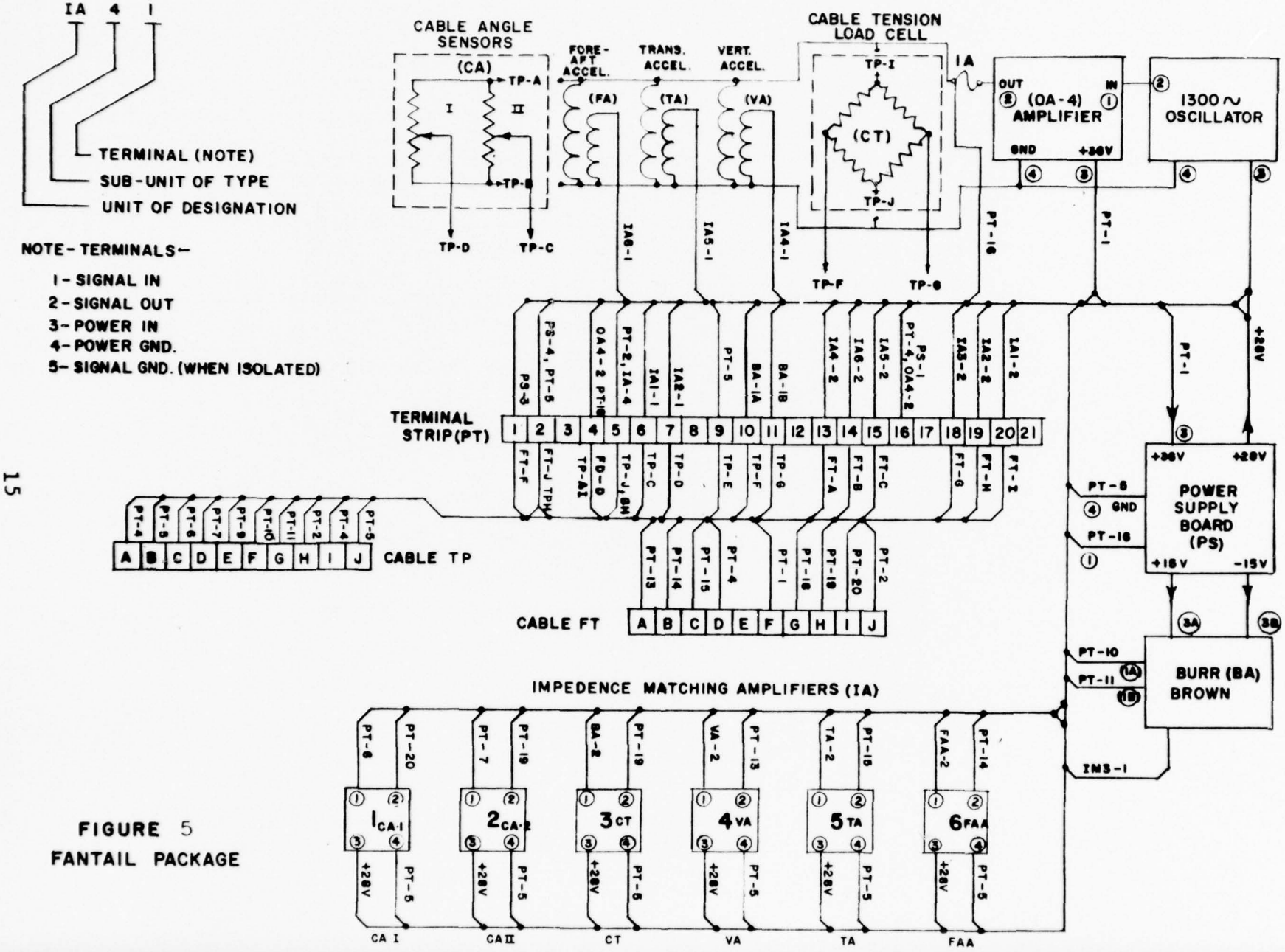


FIGURE 5
FANTAIL PACKAGE

The power supply board in the Fantail Accelerometer Package (figure 6) consists of various circuits that provide +28 vdc, +15 vdc, and -15 vdc power outputs from the +36 vdc input from the 36 vdc power supply package (A-18). The +36 vdc is decoupled, regulated to +33 vdc with a Super-Reg (A-19) and then dropped to +28 vdc which supplies power for the six impedance amplifiers. Power for the oscillator is obtained by resistive voltage dropping and then zener regulating the +33 vdc to a nominal +29 vdc, followed by decoupling. Power for the oscillator amplifier is obtained from the regulated +33 vdc. The differential amplifier requires +15 vdc -15 vdc supplies. The +15 vdc is obtained by dropping the regulated +33 vdc and regulating with a Super-Reg to +15 vdc. The -15 vdc is obtained by more devious means. The 1300 c/s output of the oscillator power amplifier (A-2) is stepped up by transformer TY88 to about 25 vac. The output is then bridge rectified, filtered, and regulated by a Super-Reg to -15 vdc.

The outside dimensions of this package are 11" x 16" x 10-1/2". An aluminum plate, part of the package, is used for mounting the package to the tow ship.

3. 36 vdc Power Supply Package.

The package contains a +36 vdc Technipower Supply (A-18), operated either by a latching relay controlled from the Central Electronics Package, or by an override switch at the Power Supply Package. The 115 vac input power is obtained from the ship. A running time meter records hours of operation. The package is housed in a metal box about 8-1/2" x 9-1/2" x 12", and contains a fan to ensure air cooling.

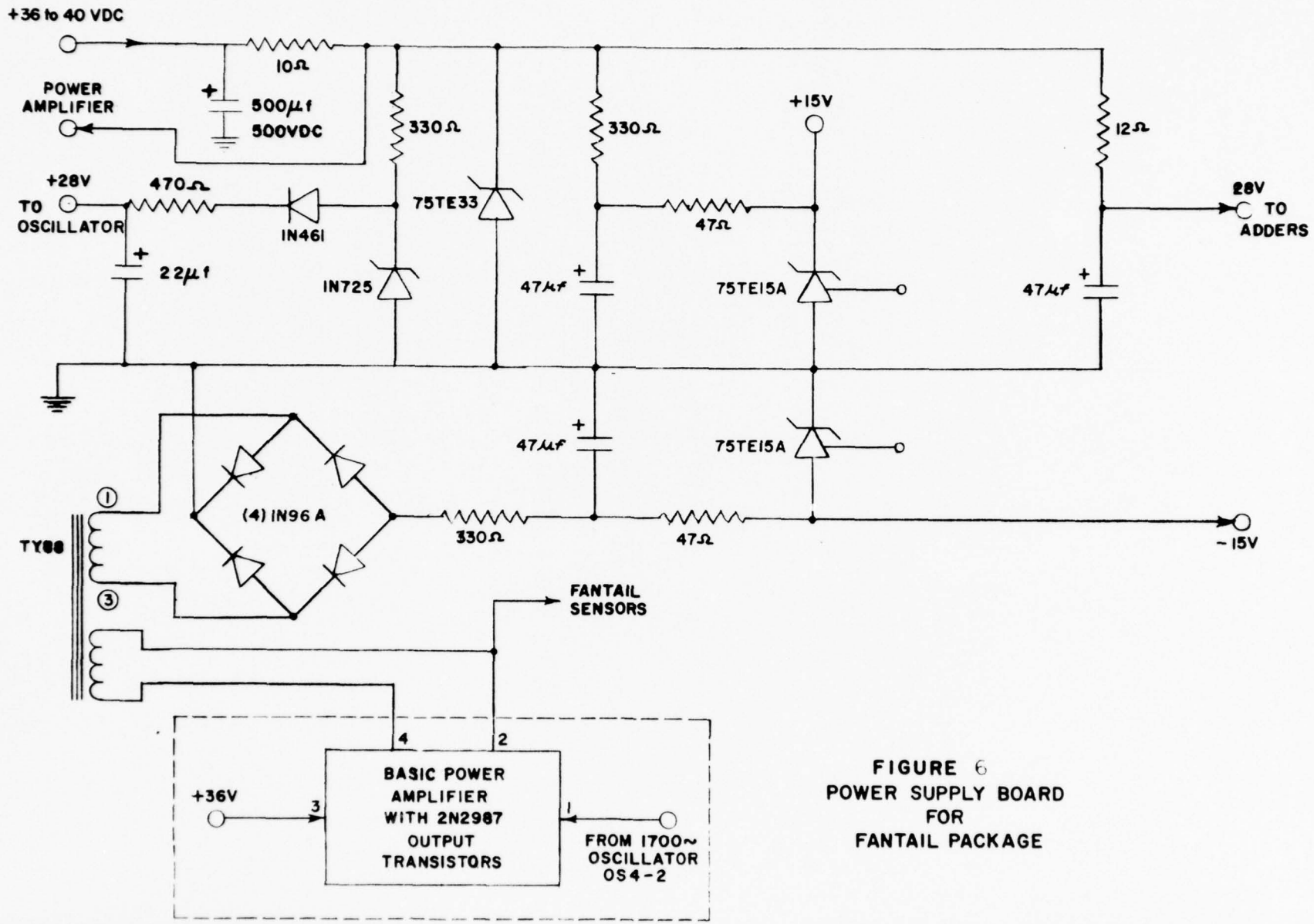


FIGURE 6
POWER SUPPLY BOARD
FOR
FANTAIL PACKAGE

4. Ship Motion Package (figure 7).

The Ship Motion Package consists of four synchros (A-17), which are electrically driven by the ship's main instrumentation; a 1700 c/s oscillator amplifier (A-2); four impedance matching amplifiers (A-4); and a 28 vdc power supply (A-18) which serves as a space supply. The ship's speed, heading, roll and pitch, are obtained with synchros repeaters connected to the ship's master synchros. Each synchro drives a potentiometer that amplitude-modulates the 1700 c/s oscillator signal and drives an impedance matching amplifier as in the Fish and Fantail Packages. Each amplifier in turn feeds the cable connected to the adders in the Central Electronics Package. Power for the oscillator, oscillator amplifier, and impedance matching amplifiers is obtained from the Central Electronics Package. The Ship Motion Package has dimensions of 21" x 9-1/2" x 12" and also contains a fan to ensure air circulation.

5. Central Electronics Package and Associated Equipment, figure 8.

The Central Electronics Package consists of the electronics that condition incoming signals for recording on the tape or display on the chart recorder. The package is mounted on a chassis in the Sanborn Chart Recorder Rack.

Adders similar to those in the Fish Instrument Package form part of the Electronics. Each adder has three inputs: one input is comprised of the three added signals from the fish, the second is one of the 1300 c/s modulated signals from the Fantail Package, and the third is one of the 1700 c/s modulated signals from the Ship Motion Package. Signals from

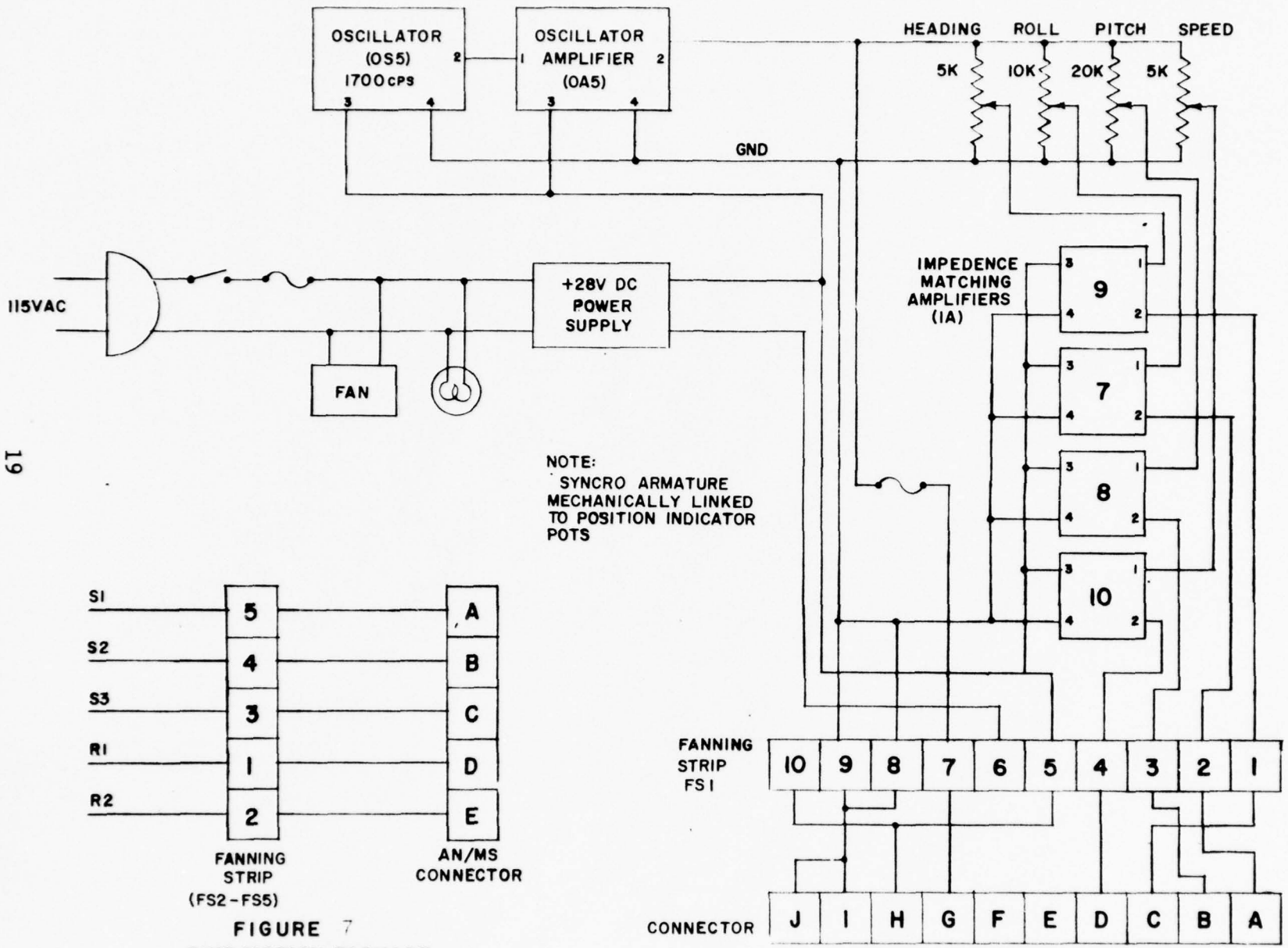


FIGURE 7
SHIP MOTION PACKAGE

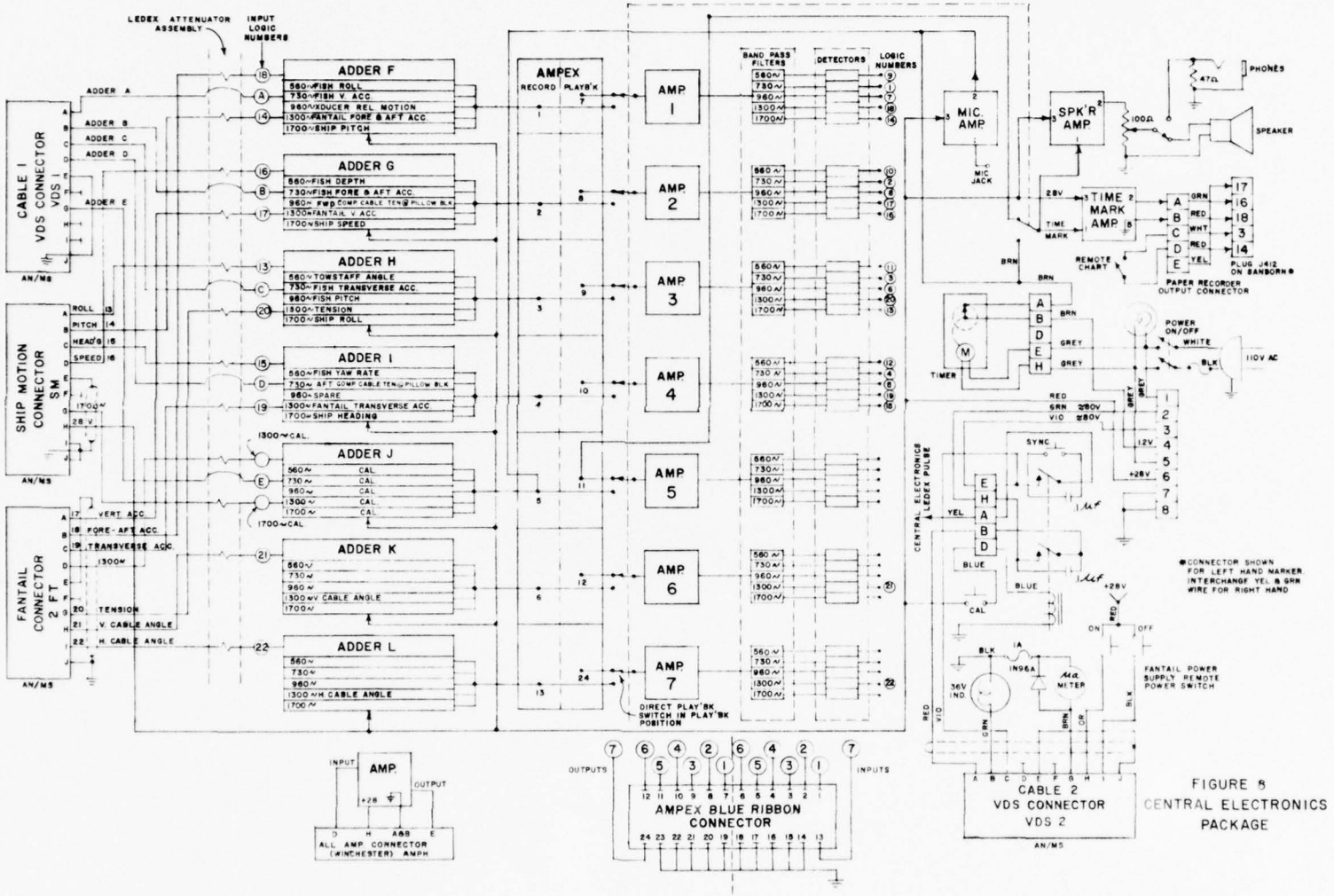


FIGURE 8
CENTRAL ELECTRONICS PACKAGE

the impedance matching amplifiers (A-4) and from the Fantail and Ship Motion Packages are first fed through a motor-operated Ledex switch and attenuators (as in the Fish Package) before being applied to the adders. The attenuators reduce all maximum signals to a uniform level that does not overdrive the adders. An additional adder handles signals from each oscillator, each of which has already been attenuated. A separate adder is used for each of the cable angle signals.

Each of the seven adder outputs is connected to one of the magnetic tape recorder (A-21) inputs, and also to a DIRECT-PLAYBACK switch. All the data are recorded on the tape recorder in the FM mode. A switch is provided to short circuit all tape recorder inputs as part of the calibration sequence to provide a dc zero reference.

The DIRECT-PLAYBACK switch selects either the adder outputs or the tape recorder tape outputs to be fed into power amplifiers (A-2). Each power amplifier feeds paralleled bandpass filters (A-5), one tuned to each carrier present in the amplifier output. Each bandpass filter is followed by a detector circuit (A-6), which then rectifies and averages the signal. The result is a variation proportional to the original sensor signal. The signal is then fed to the paper chart recorder (A-22) for visual readout.

To provide other information, a voice channel is employed. The microphone drives a small solid-state preamplifier that is connected to the same adder as the reference oscillator signals. For voice playback, a power amplifier (A-2) is used, followed by a volume control potentiometer and a switch to select either a speaker or earphone jack.

For a timing mark, an industrial timer is used to switch -1.2 vdc obtained from the Central Power Supply (A-18). The timer provides a short, -1.2 vdc pulse every 10 seconds. This pulse is recorded on the voice and unmodulated oscillator signal channel of the tape recorder. For this separate marker, the DIRECT-PLAYBACK switch selects either the pulse fed to the tape or the pulse playback from the tape and directs it to a time-mark amplifier which provides isolation and inversion. Thus, the marker is recorded in the voice channel and also on the chart paper margin during readout.

A small microammeter, mounted on the front panel, registers the current flow through a resistor in the main fish electronics container (A-10). This current flow is proportional to the moisture in the Fish Instrument Package. Voltage for this moisture detector is -80 vdc, supplied from the Central Power Supply.

Fantail and Ship Motion electronics calibration is performed, as in the fish, through a Ledex switch. The 1300 c/s and 1700 c/s oscillator signals are brought up to the Ledex switch. Resistive dividers selected by the Ledex attenuate the oscillator signals to nine-tenths, five-tenths, or one-tenth of the oscillator output levels. These attenuated signals are then applied to the adders, substituting for the sensor signals. Thus, both a linearity and absolute gain check is provided. The fish and ship Ledexes are stepped in unison. In the event the Ledex switches lose synchronization, a "sync" switch is provided to step only the ship Ledex until the two are synchronized.

Power for the Central Electronics is provided by the Central Power Supply (figure 9), also located in the chart recorder rack. A +28 vdc modular supply (A-18) provides

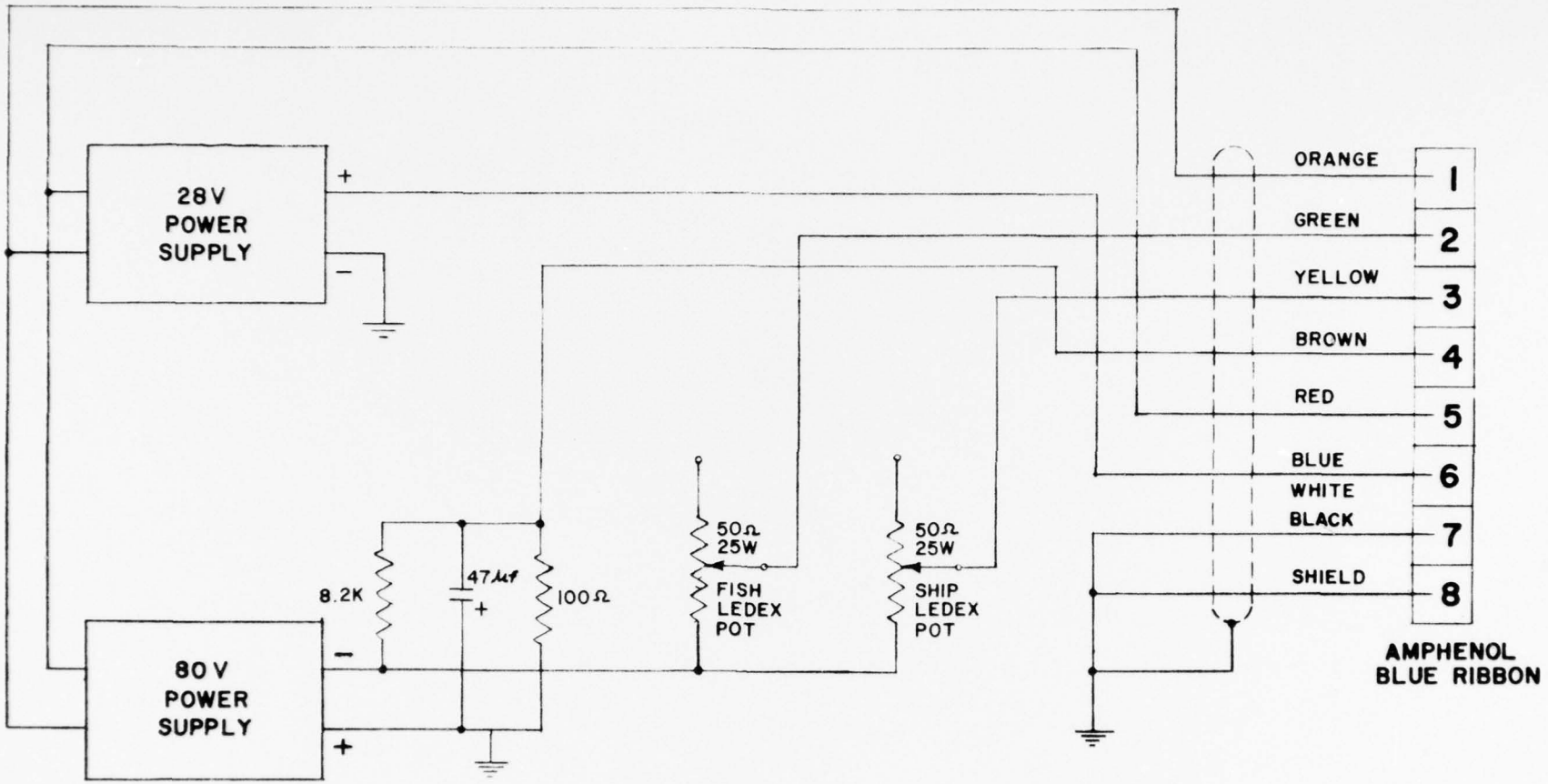


FIGURE 9

CENTRAL POWER SUPPLY

power for the solid-state components in the Central Electronics Package and also for the Ship Motion Package. To provide power for the moisture detector, Ledex switches, and time marker, the 115 vac line voltage is rectified by a diode bridge and capacitively filtered to produce a basic -80 vdc supply. Variable power-resistors provide a series voltage drop to provide the proper actuation voltage for the Ledex switches. A voltage divider drops the voltage to -1.2 vdc for the marker signal, which is then isolated by a 47 μf shunt capacitor. The -80 vdc used for the moisture detector voltage is taken off the central Ledex motor supply.

A 6-foot high, 19-inch rack holds the Sanborn chart recorder, the central power supply, and the Central Electronics Package. A fan ensures cooling and air circulation.

III. INSTALLATION OF EQUIPMENT ON TEST SHIP

A. PACKAGE AND SENSOR INSTALLATION

1. Fish Instrument Package

This package is installed inside the towed fish body, normally just aft of the sonar transducer. It is securely fastened by rigid brackets fabricated to suit each particular fish configuration. The package requires rigid coupling to the fish body, as well as precise alignment of the principal axes of the package to those of the fish. This is accomplished by leveling the fish with an accurate bubble level in both the fore and aft and the transverse directions, then shimming the Fish Instrument Package until level, and adjusting its heading axis to correspond with that of the fish.

Attached to the Fish Instrument Package are four cables. These are attached to bulkhead connectors on the instrument package and are pressure tested to ensure water-tight integrity prior to installing the package in the fish.

2. Other Fish Sensors.

Several sensors are operated externally to the main instrument container and are connected electrically to it by means of Marsh Marine cables.

The depth transducer can be mounted in any convenient location within the fish, and is connected to the Fish Package by the appropriate cable.

The sensor that measures the relative angular displacement between the fish body and the pendulously supported sonar transducer consists of a single-turn potentiometer enclosed in a watertight housing with a sealed shaft penetrating one end. The sensor is coupled by suitable mechanical linkage to the fish body and to the transducer. Typically, the shaft is attached to the fish body and the sensor housing to the sonar transducer. In this manner, the relative angle or motion can be obtained.

A similar sensor is used to measure tow staff angle. Typically, the shaft is attached to the tow staff through a direct shaft coupling, while the housing is attached to the fish body.

Strain gaged pillow blocks are used to measure the tow cable tension at the fish. The installation procedure is quite different for each specific equipment tested, and hence, will not be covered in this manual. Specific instructions for each installation are made available by the manufacturer of the strain gaged pillow blocks.

Each sensor is electrically connected to the fish instrument package through two of the four watertight cables attached to it. Of the remaining two cables, one is available for connection to the sonar transducer to monitor instrumentation contained therein. The other is mated to the tow cable end plug and serves as the electrical connection to the ship. The junction between this cable and the tow cable plug is made in a watertight cannister specially fabricated for each tow cable.

3. Ship Tow Point Cable Sensors

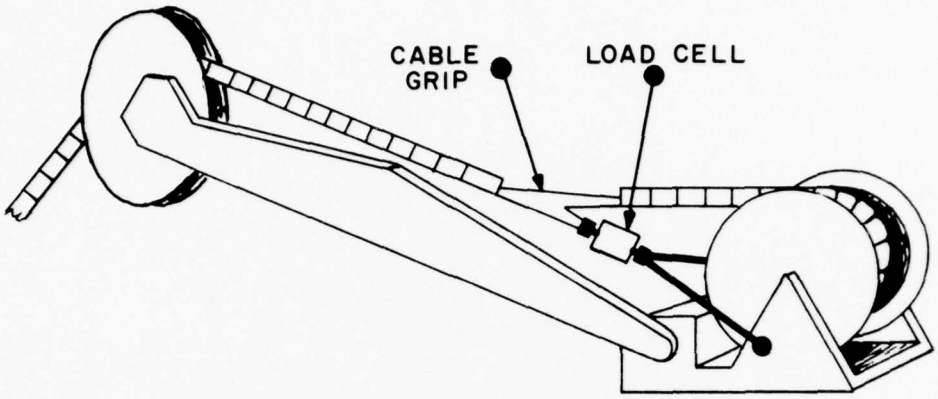
The method for measuring the cable tension at the ship depends on the type of hoist mechanism employed and the

manner in which the hoist lends itself for this measurement. A 50,000 pound capacity, strain gaged load cell has been used on two different types of equipment for this measurement. For instruction purposes, these two methods for cable tension, (see figure 10) will be discussed briefly.

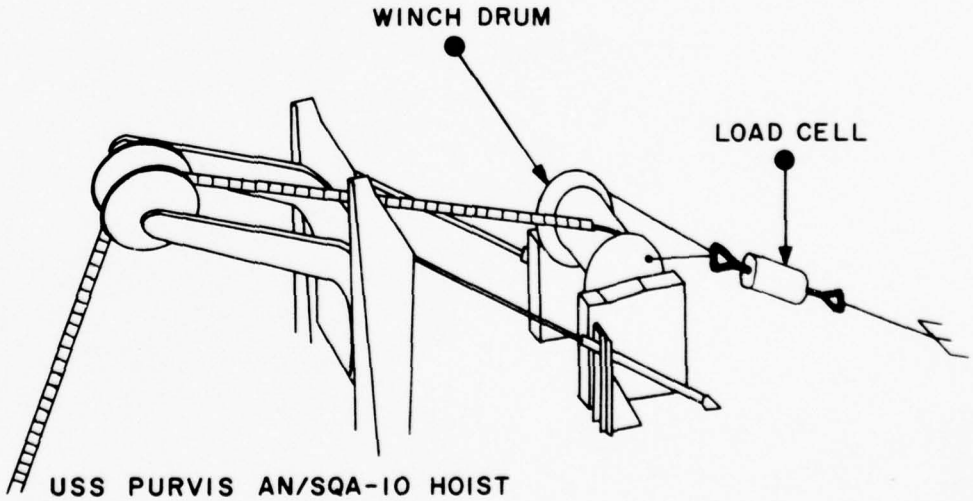
On an AN/SQA-10 hoist mechanism, the tension in the cable was determined from a measurement of the torque on the winch drum. This was accomplished by attaching a Y bridle made of wire rope to the flanges on each end of the drum. With two legs of the Y attached to the drum, the third leg was secured to one end of the load cell. The other end of the load cell was secured to a suitable strength member on the deck of the ship.

With the drum brake off, the torque caused by the tow cable tension was resisted by the bridle and load cell. The load cell measurement was then proportional to the tension in the tow cable by the ratio of the radius on the flange, at the point of connection to the radius of the drum.

The other method used for measuring cable tension employed the use of cable grips to attach one end of the load cell directly to the tow cable. The other end of the load cell was connected to the framework of the hoist mechanism. The total tension of the tow cable was placed on the load cell resulting in a direct measurement of cable tension. The load cell and cable grips were attached while the drum carried the load; the drum was then rotated so as to switch tension to the load cell.



USS WITEK AN/SQA-11 HOIST



USS PURVIS AN/SQA-10 HOIST

FIGURE 10-CABLE TENSION LOAD CELL INSTALLATION AND USE

4. Tow Cable Angle Sensors

Two angles with respect to the tow cable are to be measured. One is the angle that the cable makes with the water plane; the second is the angle in the water plane that the cable deviates from the vertical fore and aft plane. The solid angle formed by the tow cable from the point of tangency with the towing sheave must be determined. This is accomplished by measuring the distance between a point on the tow cable and three other points. Two of these points are fixed on a line perpendicular to the vertical plane running fore and aft through the ship, so it is only necessary to determine the distances.

These two distances are measured with the cable angle sensor box which is mounted in a convenient location on or near the hoist. The nylon covered cables from the sensor box are lead through pulleys to the end points of the distances to be measured (the location of these end points relative to the center of the tow sheave must be accurately known). For each run, the nylon covered cables are attached to a point on the tow cable by appropriate fasteners. In order to permit solution of the geometric problem and to find the cable angles, the distance between the point of attachment of the nylon covered cables and the tow point must be known. Since the diameter of the towing sheave is known, it is sufficient to measure this length with the tow cable vertical (ship speed, 6 knots or less) and hence with the tow point on the horizontal diameter of the tow sheave. This measurement can be made by any convenient method some time after attachement of the nylon covered cables to the tow cable.

5. Fantail Accelerometer Package.

The Fantail Accelerometer Package is installed as near as possible to the fantail of the ship. Usually the ram room is a suitable place. The package is securely attached to a vertical bulkhead so that the large aluminum base faces forward (electronics and fan aft), with its long dimension athwartship. The package is then aligned with the ship to allow measurement of the proper components of ship acceleration. This is accomplished with the aid of an accurate bubble level mounted in a protractor head as follows:

a. Determine the attitude (pitch and list) of the ship. (Note that the ship must be stationary.)

b. Align the base plate so that it would be in a vertical plane if the ship were level in the pitch direction.

c. Adjust this vertical plane so as to put it perpendicular with a horizontal line running lengthwise through the ship. This is usually accomplished by assuming the bulkhead is truly athwartship, and adjusting the base plate to be parallel to the bulkhead in that direction.

d. Adjust the top edge of the base plate that is marked as a reference surface so that it would be horizontal if the ship had no list.

After alignment, the cabling is connected to the Fantail Accelerometer Package, thus completing its installation.

6. Ship Motion Package Installation

The Ship Motion Package should be located convenient to the points of connection for the ship motion synchro signals of roll, pitch, speed, and heading. A 115-vac electrical output should also be available nearby. The package, weighing about 50 pounds, should be secured, with the front panel and all connectors readily accessible. The package should be mounted only in the normal horizontal position.

7. Central Electronics Package and Recorders Installation

The Central Electronics Package, Sanborn chart recorder and Ampex tape recorder are located together at a central recording station. The Central Electronics Package is mounted in the Sanborn chart recorder cabinet. The cabinet, about six feet high and 750 pounds in weight, must be secured at both top and bottom to the ship's structure. Sufficient space must be left in front for the operator, and access space must be provided in the rear.

The Ampex tape recorder must be mounted adjacent to the Sanborn chart recorder for electrical connections and for easy access for data collection. It also must be securely tied down.

B. WIRING INSTALLATION

The electrical installation aboard ship consists of connecting the various instrumentation packages together and then systematically checking them before applying power. Each installation is unique due to the differences in ships and the VDS installation. It should be confirmed before making any actual connections that all equipment involved has the

power to it turned off and the remote switches tagged. The terminals involved should then be checked with a voltmeter to verify that they are dead with respect to ground as well as each other.

Figure 11 shows a typical installation. The Central Electronics Package, Sanborn paper recorder, and Ampex tape recorder are located in a convenient location where the VDS terminations are accessible, in this instance, the main sonar compartment. The Ship Motion Package is located in a place central to the connection points for the ship quantities of roll, pitch, heading, and speed. In this case, heading and speed were available in the main sonar compartment; roll and pitch in an adjacent compartment. Care should be exercised to ensure connection to the proper speed synchro repeaters. The ship speed should be taken from a single speed synchro, while the heading should be from a 36-speed synchro. Ship roll and ship pitch are also obtained from ship's synchros. In this example, ship's roll and pitch were obtained from the ship's fire control computer, although the ship motion information originated in the ship's stable element. In most ships, stable element is not operated continuously so a check with the proper ship personnel preceding any data runs is mandatory.

The 36 volt (nominal) dc Power Supply Package for the Fantail and Fish Packages can be located remote from the Central Electronics, since it can be turned on and off from the Central Electronics Package. It must be located convenient to a junction box where the cables for the Fantail and Fish Packages are accessible on terminal blocks. In this example, the junction box is located in an aft sonar equipment room where the VDS cable terminates from the hoist. From the junction box, other cables run to the sonar control room for the fish

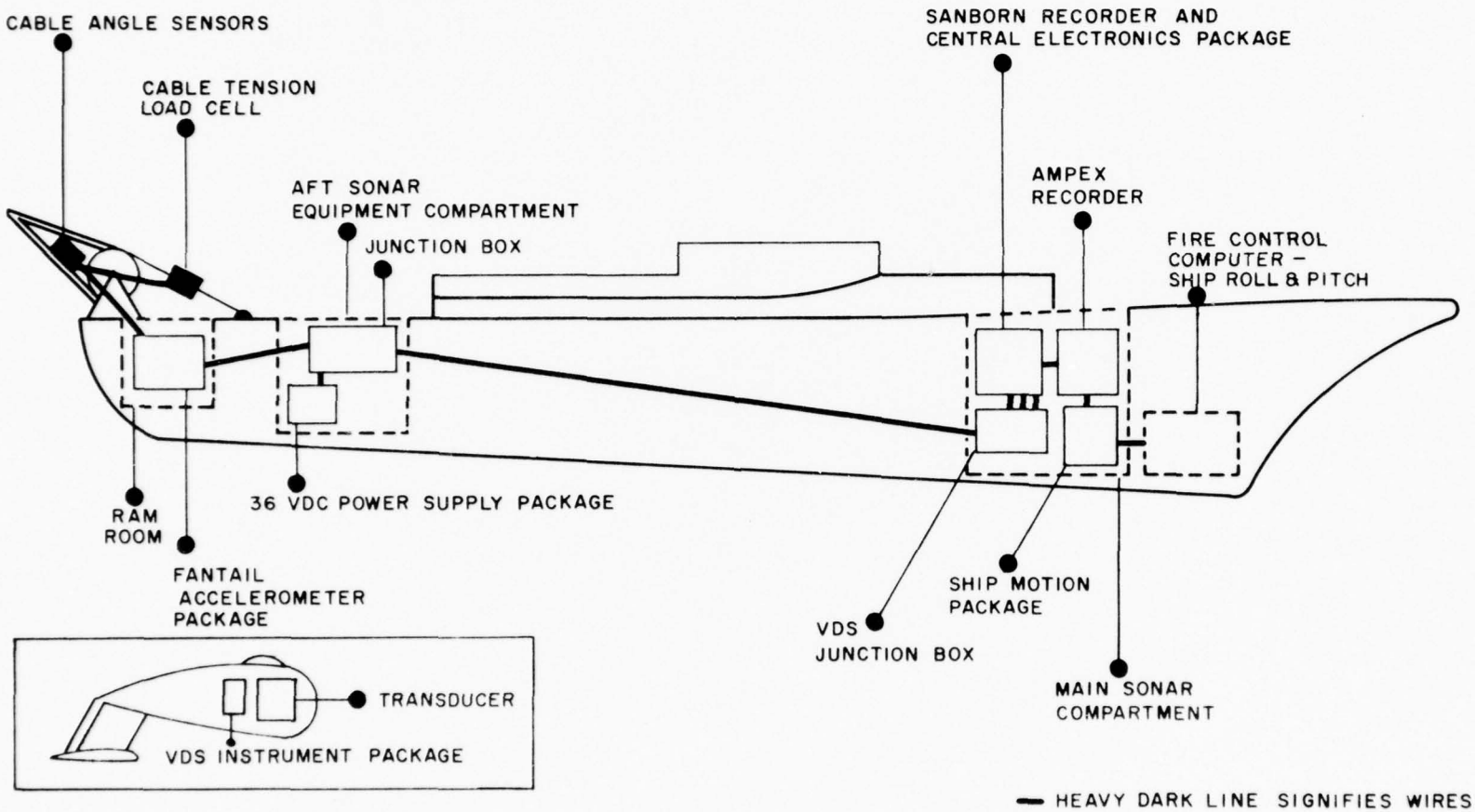


FIGURE II - TYPICAL INSTRUMENT LOCATIONS

transducer signals. The Fish Instrument Package is operated from spare and borrowed conductors in the tow cable. Hence, it is convenient to supply power at this junction box. A minimum of four conductors must be returned to the Central Electronics Package for the Power Supply remote operation.

While all the tow cable conductors connect in this junction box, not all the conductors are carried to the main sonar compartment. Therefore, a shortage of conductors is often encountered in returning the Fish Instrument Package conductors to the Central Electronics via the existing VDS cabling. A minimum of 12 conductors is required for the Fish Instrument Package functions alone, exclusive of power.

The Fantail Accelerometer Package, usually located in the ram room, houses electronics for self-contained accelerometers and remotely located tow point cable angle and tow cable tension sensors. A single multiple shielded-pair cable is connected from the Fantail Accelerometer Package to the cable angle device and carries excitation and return for the cable angle sensors and load cell, the latter being connected to the cable angle device by a two shielded-pair cable. A ten conductor shielded cable then connects the Fantail Accelerometer Package to the junction box where the VDS tow cable terminates. A minimum of seven Fantail Package conductors must be returned to the Central Electronics, exclusive of power.

Considering the Power Supply, Fantail, and Fish Packages, a total of 23 conductors are required between the junction box in the main sonar compartment and the tow cable termination junction box. In addition, if the voltage moniters from the Fish Instrument Package is desired in the main sonar compartment junction box, three additional lines are required. If the

available conductors to the main sonar compartment are not sufficient, additional cabling must be run.

Before connecting any equipment to either junction box, each conductor to be used between the junction boxes should be checked for continuity. Continuity should also be checked between the fish end of the tow cable and the main sonar compartment junction box, as well as between the main sonar compartment junction box and the Fantail Package. All connections should then be made to the junction boxes with careful records kept of wires disconnected and changes made. All disconnected and changed wires should be tagged with their original termination. With all cables disconnected from the respective Packages, continuity should be checked from connector to connector to ensure that no wires have been broken and to ensure against errors.

C. INITIAL SYSTEM CHECK OUT

After continuity has been checked for every conductor, all connectors should be carefully mated to their proper package bulkhead connector.

The chart recorder and tape recorder should be allowed to warm-up approximately one hour. After this time, the zero position, attenuator balance and gain should be set as per the Sanborn operation manual. The fans in the Ship Motion and Fantail Accelerometer Package should be turned on.

On the front panel of the Central Electronics Package, the main power switch should be off, the DIRECT-PLAYBACK switch should be in the DIRECT position, the SPEAKER-PHONE switch in the desired position, and the volume control turned maximum clockwise. Turning the main power switch on, the adjacent

lamp should light, a single tone should be heard, and the moisture meter should indicate between 5 and 15 microamperes. For failure of any of these functions, immediately turn off the main power switch and consult the troubleshooting section.

If everything is indicating correctly, monitor the ship motion quantities after checking with the Internal Communications compartment to ensure the ship's roll, pitch, heading, and speed are on.

For the Sanborn chart recorder, (the gain set for four major divisions for 20 mV cal, and the attenuator set on 200), full scale deflection of the writer pen corresponds to approximately full-scale signal. The Sanborn channels should be connected to monitor the ship motion quantities. In the Ship Motion Package, the coupling sleeve between the synchros and the attached potentiometers should be loosened. At this time the Ship Motion Package synchro repeaters can be tested to see if they are receiving a signal by attempting to turn the synchro shaft. If the shaft turns easily, no signal is being received. Difficulty in turning the shaft plus an elastic restoring torque indicates a received signal. For excessive heading of any synchro, refer to the troubleshooting section. While turning each pot attached to each synchro, check to see if a corresponding change occurs in the paper recorder write-out. Note that the ship roll and pitch pots are tapped pots and are set up so that the zero to full scale deflection occurs in only a 30^{o} of 45^{o} portion of rotation. For calibration of ship roll and ship pitch, refer to calibration section, page 39.

After the ship motion quantities are verified as working correctly, connect the paper recorder to monitor the oscillator

outputs from the Fish and Fantail Packages, the Fish Instrument Package roll and pitch gyro outputs and the Fantail Package cable tension and vertical accelerometer signals. With the paper recorder running at 2.5 mm/sec for ease in observation, turn on the main power for the Central Electronics and then depress the ON button for the 36 vdc power supply momentarily. The indicator lamp should light and five tones should be audible. An approximately half scale deflection should occur on each of the four oscillator monitors. The fish roll and pitch write-out should indicate an oscillation that rapidly decays to an approximately half scale steady signal. Fantail cable tension should indicate near zero, while the Fantail Accelerometer outputs should be about half scale. Abnormal behavior on any output dictates immediate shutdown and investigation such as is outlined in the troubleshooting section should commence. If the quantities appear normal, all other outputs should be observed and any irregularities investigated. The Fish Instrument Package inverter and electronics dc voltages monitors should next be checked in the junction box where the tow cable terminates. These two conductors, along with the Fish Instrument Package ground monitor, are simply returns and do not carry any current. First, while observing the voltage between the fish ground monitor and inverter voltage monitor, adjust the 36 vdc Power Supply Package internal voltage adjust for an average 28 vdc inverter voltage. After this adjustment is made, the Fish Package electronics voltage must be adjusted to ensure proper operation of the input voltage regulator. This is done by loosening the lock nut on the FISH ELECTRONICS ADJUST potentiometer shaft and rotating the shaft completely counterclockwise. Then while observing the dc voltage of the electronics voltage monitor with respect to fish ground monitor, slowly rotate the control

clockwise until the voltage reaches about 24 volts and further rotation produces no more voltage increase. Note the shaft position at the point where the voltage becomes constant. Rotate the control then exactly 1/8 turn further clockwise. This ensures proper regulator action.

The next function to be checked is the Ledex solenoid switch used for an electronics linearity and gain check. Momentarily press the switch labeled CAL on the front panel of the Central Electronics Package, and all signals on the 730 c/s carrier should indicate approximately one-tenth full scale on the chart recorder. Signals on all other frequencies should indicate approximately nine-tenths full scale. Again pressing the CAL switch should change all signals to approximately five-tenths full scale. Once again depressing the switch should result in all signals of the 730 c/s carrier indicating nine-tenths full scale, while all other signals indicate one-tenth full scale. Depressing the button a fourth time restores all outputs to the sensor signals. An adjacent button, protected by a snap cover and labeled SYNC provides a means of stepping the signals on 1300 c/s and 1700 c/s without stepping the other frequencies, in the event the sequences are not indexed the same. In the case that any outputs do not produce a reference sequence, consult the troubleshooting section.

An additional equipment check required concerns the tape recorder. The head assembly and tape guides must be cleaned and the input-output connections to the Central Electronics package must be made. Turn the tape recorder on and allow it to warm up 5 minutes. Check to see if the phase meter on the front panel is in the proper range. If it is not, adjust the

adjacent adjustment. If the proper indication cannot be obtained, consult the tape recorder manual. Assuming the phase meter is adjusted properly, the head assembly and tape guides should be cleaned with Ampex head assembly cleaner; next, load a reel of blank tape as described in the Ampex manual. Connect the paper recorder to monitor one output of each multiplexed channel. Depress the CAL button on the front panel of the Central Electronics Package twice so that all signals indicate approximately five-tenths full scale. Energize the tape recorder DRIVE mode; then the RECORD mode. Both buttons on the tape recorder should light. Now switch the DIRECT-PLAYBACK switch on the Central Electronics Package from DIRECT to PLAYBACK. The displayed signals should remain substantially the same. Small shifts indicate minor tape recorder misalignment. For signals that disappear, or appear noisy, in the PLAYBACK mode, consult the troubleshooting section. To provide a zero reference input on the tape, a switch labeled SHORTED INPUTS is located on the front panel of the Central Electronics Package. An adjacent light indicates when the inputs to the tape recorder are shorted by the switch. With the DIRECT-PLAYBACK switch then in PLAYBACK position, and the tape recorder in RECORD mode, turning the SHORTED INPUTS switch clockwise should cause all displayed outputs to go to zero.

D. SHIPBOARD CALIBRATION

It is necessary while on board to perform various calibration operations which are either impossible or inconvenient to perform in the laboratory. Quantities to be calibrated are the ship motion quantities, tow staff angle, transducer relative motion angle, tow point cable tension, and fish pillow block tension. First the ship motion quantities require dummy signals to be set up by the proper ship personnel. These are easiest

done while the ship is in port. On request, the appropriate ship technician will simulate desired roll, pitch, heading and speed. First, zero quantities are needed: zero degrees roll and pitch, zero knots per hours, and a heading of 000. Once these quantities are available, adjust the ship motion potentiometers, attached to the synchro repeaters in the Ship Motion Package, to produce a zero deflection on the chart recorder for heading and speed and five-tenths full scale for pitch and roll. Carefully tighten the screws that lock each potentiometer shaft to its synchro shaft. Check to verify that the output deflections did not change during the tightening. This point and various other dummy inputs need to be recorded on tape for later reference and data reduction. When operating the tape recorder for data recording, a voice channel is used for identifying the signals being recorded plus other applicable data. While recording, the DIRECT-PLAYBACK switch on the Central Electronics Package should be in the PLAYBACK position to verify proper recorder operation. While using the microphone, the speaker volume control should be turned counterclockwise so that the voice is inaudible. Preceding the calibration recordings, identify the tape, ship, date, local time, operating personnel and quantities to be recorded on the voice channel. Then perform a "calibration" or reference sequence of ten seconds of shorted input data, and ten seconds of each of the three reference signals, identifying each step first. IMPORTANT: This reference sequence must also be performed every ten minutes during the calibration. A minimum of six and preferably ten points should be taken in equal increments from zero to full scale output deflection. Ten seconds of steady-state data should be taken at each point.

The potentiometers used for tow staff and transducer relative angle measurements are calibrated in the laboratory but

reference points are needed. Three points are usually sufficient: zero degress and points 3^{o} - 5^{o} in both directions of swing. These should be recorded on tape in the same manner as the ship motion quantities. Finally, the tow point cable tension and fish pillow block tensions should also be referenced by providing a recording of some "at rest" or zero data, and also two points obtained by "weighting" the fish (whose weight is known) in air and in water. Recording these points will complete the shipboard calibration.

IV. OPERATING PROCEDURES

Once the operational check-out is completed, the actual operation involves the Sanborn chart recorder, Ampex tape recorder, and the Central Electronics Package. The Sanborn and Ampex instruction manuals should be reviewed before attempting operation. If desired, the cooling fans for the Fantail and Ship Motion Packages can be left running all the time while an operator is on board. Before beginning a new series of data runs following a period of the equipment being off, certain procedures should be routine. All equipment should be turned on an allowed to warm up for at least 30 minutes. Indicator lamps and the moisture meter should be observed closely and the equipment shut down immediately in the event of malfunction. If all indicators register properly, all signal outputs should be checked for possible loss of signal or irregular indications. If all equipment is operating properly, the Ampex head assembly and tape guides should be cleaned and the Sanborn balanced and calibrated, as described in the Initial System Check Out, page 35. A minimum of 30 minutes warm up time is necessary before making any Sanborn adjustments which should be performed at hourly intervals.

Before beginning a series of data runs, a check should be made to ensure a sufficient amount of magnetic recording tape and chart paper. All data runs, "calibration" or reference sequences, pertinent information and remarks should be carefully recorded in the log book. This information should also be recorded on the voice channel of the tape recorder. Information required is as follows:

1. Name of ship
2. Date
3. Local time
4. Tape reel number
5. Amount of tow cable payed out
6. Ship speed by revolutions of the screw shaft and also by the pit log.
7. Sea state by estimated wave height
8. Particular "leg" of the test plan both by identifying name and by description.

The Sanborn chart should be operated by 2.5 mm/sec and each quantity displayed, labeled for each leg of the run. All displayed data should be taken with the DIRECT-PLAYBACK in PLAYBACK position. A "calibration" sequence should be run before each leg of the run, with the shorted input portion and each reference portion recorded for ten seconds. For progression through the switched sequence, depress the CAL button, only momentarily, for each step.

A standard routine should be established for the runs. After requesting the Bridge to proceed to the desired data run, wait until the Bridge notifies that the desired conditions are being held steady. Then record the run data as explained above, record the "calibration" sequence, and then two minutes (or what is required) of data. After identifying the condition to be recorded, such as "cal 2" or "two minutes of data" use the work "mark" to indicate the actual start of the steady-state data. Also identify the end of the run by stating such. Speak at an even voice level, holding the microphone about three inches from the mouth, tilted away from the face. At the end of each reel, record that it is the end of the tape and then rewind the reel. Before removing the reel, make certain it

is clearly labeled ON THE REEL the tape number, ship, date, and data run numbers recorded. Label the tape box in a like manner.

Whenever the fish is in the water, a close watch must be kept on the moisture meter. A sound practice is to submerge the fish to a shallow depth initially, for instance, only 50 feet. The majority of leaks will show up at a shallow depth. Vigilance must be maintained at all times, however. Once a series of data runs is completed, do not abandon observation nor shut off any power until the fish is secured on deck.

V. TROUBLESHOOTING AND MAINTENANCE PROCEDURES

The following troubleshooting section is arranged with the first portion related to the problems that might be encountered in installation and operational check-out. A second section provides information for Operator Maintenance.

TABLE 2

INSTALLATION MALFUNCTIONS

SYMPTOMS	POSSIBLE CAUSE	REMEDY
Central Electronics lamp does not ligh	Main ac power disconnected.	Connect ac power
	Lamp burned out.	Replace lamp - 7 w. 115 vac.
No tone heard with Central Electronics only on.	Ship Motion Package disconnected.	Mate connector.
	Conductor wire in cable SM broken or connected incorrectly.	Check continuity between Central Electronics and Ship Motion Package.
	Fuse(s) blown in Ship Motion Package.	Replace. If blows again, check for shorts, isolate cause and repair.
	Main Power Supply cable not connected.	Mate connector.
	DIRECT-PLAYBACK SPEAKER-PHONE switch in wrong position. Volume turned CCW.	Unless the tape recorder is connected and in RECORD mode, the DIRECT-PLAYBACK should be in DIRECT position. Turn volume control CW.

Table 2 Contd.

SYMPTOMS	POSSIBLE CAUSE	REMEDY
36 vdc Power Supply lamp does not light.	Power Supply Package disconnected.	Mate Connector.
	Lamp burned out.	Replace Lamp.
	Conductor wire in cable PS or 2 VDS or ship's wiring broken or connected incorrectly.	Check continuity between Central Electronics and Power Supply Package.
	Relay in Power Supply Package malfunctioning.	Replace or repair relay. For emergency, the switch on the Power Supply Package serves as an override.
Power Supply operates but no signals from either the Fish or Fantail Packages.	Conductor wire(s) in cable PS broken or connected incorrectly.	Check continuity between Power Supply and junction box.
Power Supply operates signals received from the Fantail but not the Fish Package.		
No power received at fish, indicated by inverter and electronics monitors voltage check.	Wiring error in cable terminating junction box.	Check wiring in junction box.
Power is received fish, indicated by inverter and electronics monitors voltage check, but no Fish Signals.	Broken wire or wiring error in cable 1 VDS or either junction box.	Check continuity and wiring between Central Electronics and junction boxes, especially ground, signal ground, and the adder signals.
Power Supply operates. Signals received from the Fish but not the Fantail Package.	Broken wire or wiring error in cables 1 FT or 2 FT or in either junction box.	Check continuity and wiring.
No indication or negative indication of moisture meter.	Broken wire or wiring error in cable 2 VDS or either junction box.	Check continuity and wiring between Central Electronics and junction boxes.

Table 2 Contd.

SYMPTONS	POSSIBLE CAUSE	REMEDY
Excessive heating of synchro repeater in Ship Motion Package (normally operates warm).	Stator connection wired incorrectly.	Check and correct stator wiring.
No "calibration" sequence in either fish or shipboard quantities.	Broken wire from CAL button.	Check and repair.
	Failure in firing relay.	Repair or replace. Can be fired by hand in emergency.
No "calibration" sequence in shipboard quantities only.	Broken wire to Ledex switch in Central Electronics Package.	Check and repair.
	Polarity to Ledex reversed.	Check and correct.
	Shorted diode across Ledex coil.	Check and replace.
No "calibration" sequence in fish quantities only.	Broken wire or wiring error in cable 2 VDS or either junction box.	Check continuity and wiring between Central Electronics and junction boxes.
	Polarity to Ledex reversed.	Check and correct.
	Shorted diode across Ledex coil.	Check and replace.

TABLE 3

CENTRAL ELECTRONICS PACKAGE SIGNAL MALFUNCTIONS

Signal failures as indicated by the Sanborn display are easily localized. First make certain that the failure is not in the Sanborn by interchanging channels.

SYMPTON	POSSIBLE CAUSE	REMEDY
All signals on the same frequency are out. Oscillator output of that frequency is also dead.	The oscillator, oscillator amplifier or amplifier fuse is out.	Check fuse, and output of each unit, also input power. Replace fuse, repair or replace oscillator or amplifier as required.
The three fish signals on the same channel are out.	Adder return wire from the fish is broken or incorrectly wired.	Check wiring and continuity between the Central Electronics and both junction boxes.
All 5 signals on one channel are out.	Central Electronics adder, bandpass amplifier or associated wiring at fault.	Check wiring, modules. If faulty, repair or replace.

To provide a means to check the oscillator waveforms, and output, labeled CAL-AC, is available on the front panel. Below the output jack is a switch that selects the desired frequency. Also provided is another jack labeled SIGNAL-AC, that permits observation of one signal of each channel as selected by the switch below the jack. Both of these test jacks permit observation of the waveforms after they have been separated by their respective bandpass filters, but before they have been demodulated by the detector circuit.

TABLE 4

AMPEX TAPE RECORDER MALFUNCTIONS

Complete information and instructions for the Ampex tape recorder are contained in the manufacturer's manual. However, common problems and malfunctions are listed below for convenience.

SYMPTOMS	POSSIBLE CAUSE	REMEDY
Outputs are very noisy.	Head assembly and tape guides dirty.	Clean head assembly with Ampex Head Assembly Cleaner. Clean all rollers and tape guides with alcohol.
	Tape threaded incorrectly.	Rethread tape. With the red lever cocked, the tape should pass outside all heads and guides.
Tape speed erratic.	Tape reel warped.	Replace tape reel.
	Phase in servo loop improperly adjusted.	Set the screwdriver adjustable potentiometer adjacent to the phase meter for proper indication of the meter.
Some but not all channels dead or noisy.	Dirty printed circuit contacts on modules.	Interchange working and dead channel inputs to determine if in RECORD or PLAYBACK module. Make and break contacts on suspected module, or interchange with a functioning one.

A. OPERATOR MAINTENANCE

The operator maintenance consists primarily of cleaning the head assembly and tape guides on the Ampex tape recorder and periodic alignment of the Sanborn dc preamplifiers.

The tape head assembly should be cleaned with Ampex Head Assembly Cleaner using a cotton tipped swab. All rollers and tape guides should be cleaned with Ampex Head Assembly Cleaner or denatured alcohol, using a clean lintless cloth.

The Sanborn dc preamplifiers should be aligned, according to the instruction book, about every hour. Normally, gain should be set at four main divisions and the attenuator set on X200. Since only eight signals are displayed, all other outputs should be monitored periodically to detect possible failure.

A constant watch must be made of the moisture meter. At any sign of a leak, the meter will rise rapidly and peg full scale. The equipment must be shut down immediately, and the Bridge and the fish hoist operator immediately requested to retrieve the fish at once.

APPENDIX A

SYSTEM COMPONENTS

In this section the various components of the instrumentation system are described. The components designed and fabricated by TRACOR are described in considerable detail, while only the essential characteristics of the commercially available components are given. The various devices will be discussed, and some of the effects of connecting devices into a system will be noted.

A-1. Oscillator

Solid State Electronics Company Model S-200 are used. Five frequencies (560, 730, 960, 1300, and 1700 c/s) are used in this system. The oscillators prove to have good frequency stability. Nominal output amplitude is about 2 volts rms, but the amplitude is a direct function of supply voltage and load. It is necessary to decouple the power to each unit and to shunt the input of the amplifier that follows each oscillator with a small capacitor (0.001 uf).

A-2. Power Amplifier

The requirement for a low output impedance amplifier capable of delivering about 1 watt exists in several places in the system. Therefore, TRACOR has designed and built an amplifier to meet the requirement. The basic circuit used is shown in figure A-1. The gain of this circuit proves to be quite independent of temperature, with only about 1% variation over the expected operating range of 20°C to 85°C.

	OUTPUT TO B.P. FILTERS	OSC. AND SPKR. AMP.
R_1	18K	10K
R_2	12K	18K
R_f	270K	~33K

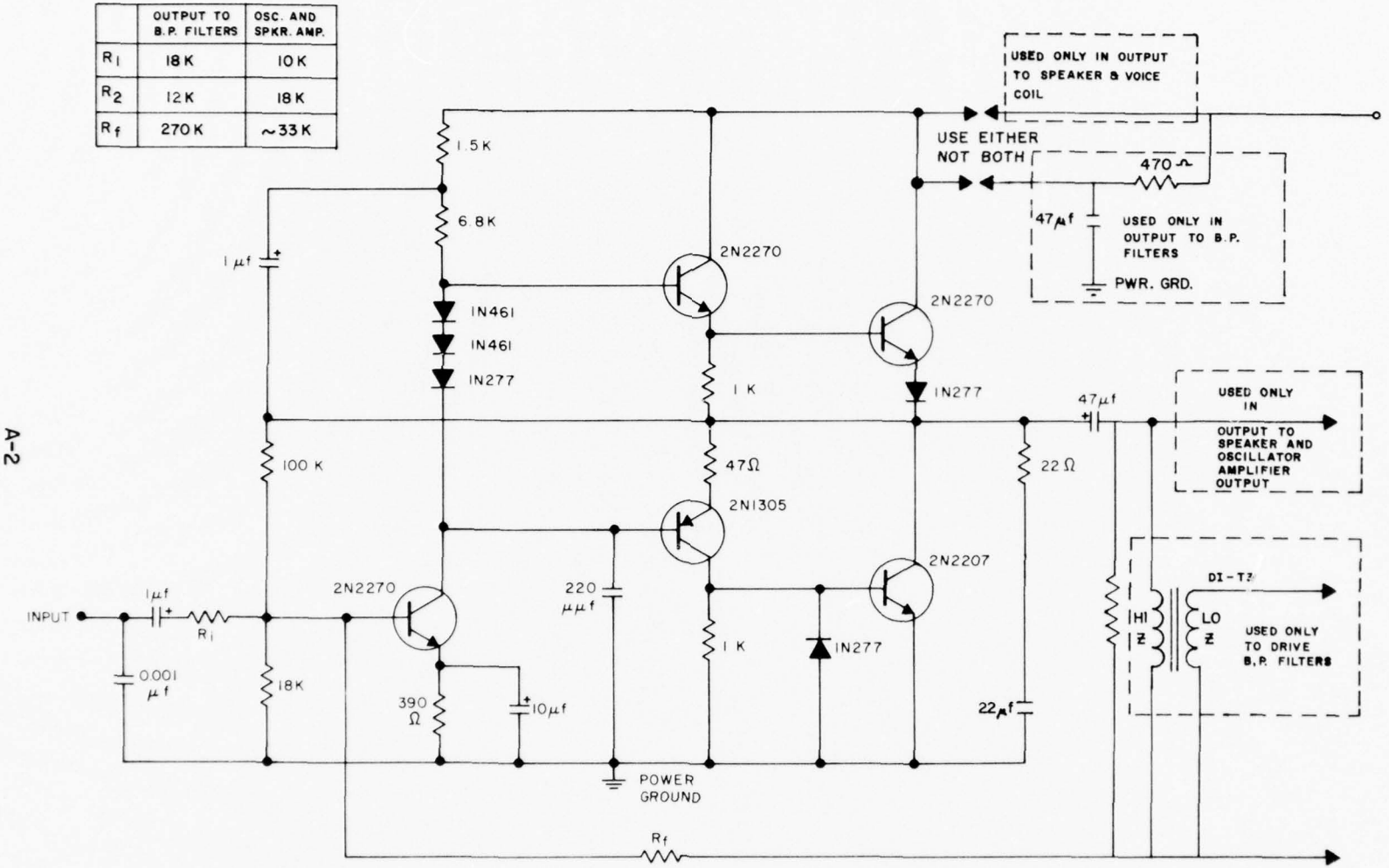


FIGURE A.1 - BASIC POWER AMPLIFIER

The gain of this amplifier is essentially independent of power supply voltage, as long as the signal is small enough to prevent clipping. For the expected minimum power supply voltage of 24 vdc, this amplifier can deliver 6 volts rms, with about a 10% margin in supply voltage about the point of output clipping. Since 6 vac proved to be adequate for all transducers used, this voltage has been selected as the reference. When these amplifiers are used to amplify the oscillator outputs, the resistor R_f is selected to give an output of exactly 6.0 volts. Once an amplifier is placed in the system, loading of the amplifier is essentially constant and thus the final selection of R_f is made with the system in operation. A disadvantage of this amplifier is that it loads the dc supply with a pulsating current (a half-wave rectified sine wave) and thereby requires decoupling. Also, the amplifier has no inherent overload protection, since its output impedance is less than 1 ohm. Each sensor, though, is independently fused so that an output short removes only the sensor(s) involved.

This amplifier is primarily used as a power amplifier between the oscillators and transducers. However, the amplifier is also used as the final output amplifier to drive the narrow-band filters that separate the signals into single frequencies for chart recording. In this application, a large output amplitude is required to provide detector linearity over a large dynamic range. By using a UTC transformer, Model DI-T3, a 3-to-1 boost of output voltage is obtained with an output impedance of less than 100 ohms. To obtain adequate gain, the feedback resistor is selected for an overall gain of 17.5. The amplifier is also used to drive loudspeakers for voice playback.

A-3. Null-Bias Circuit

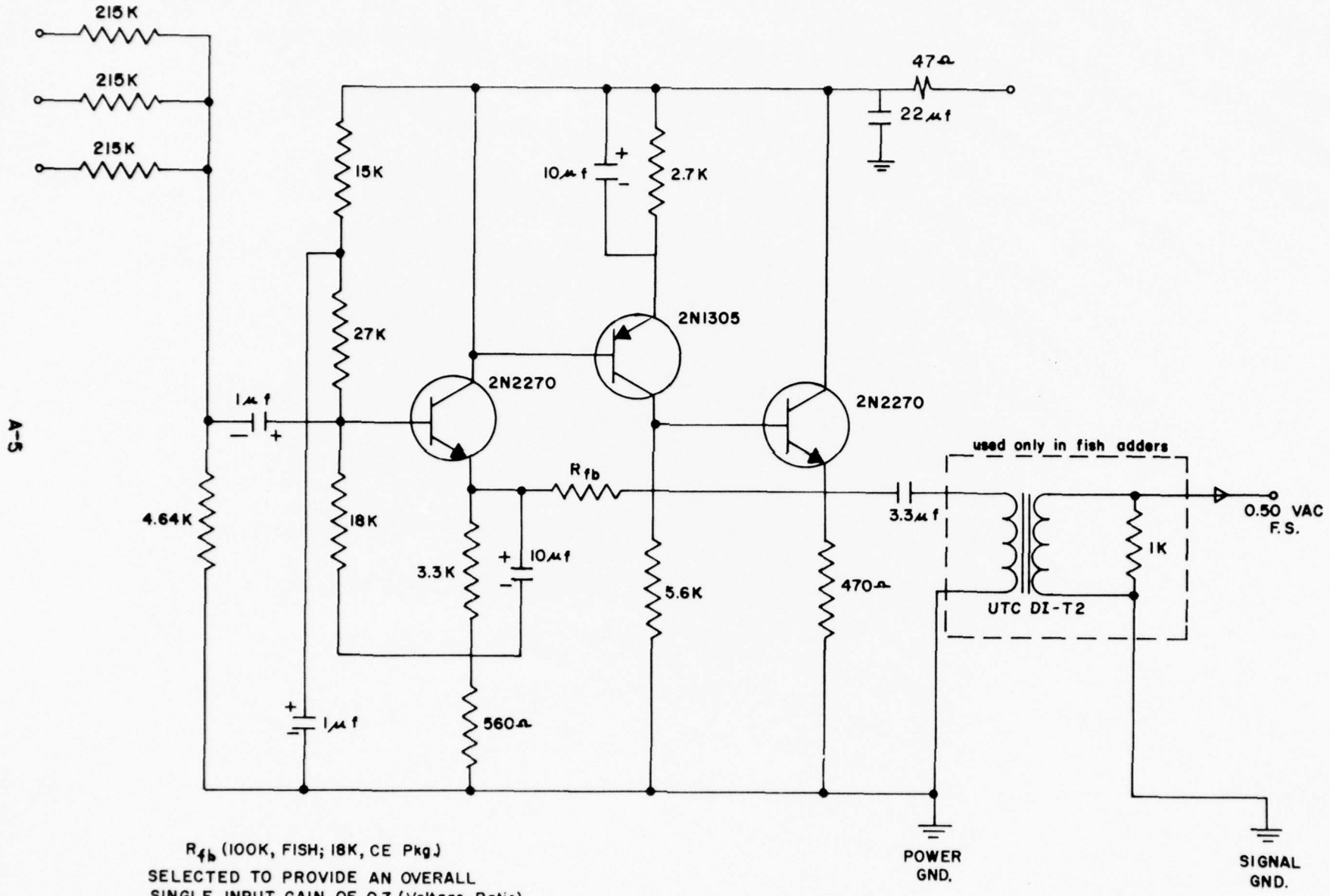
The null-bias circuit provides a means of shifting the electrical null point of the yaw rate gyro and the roll and pitch outputs of the vertical gyro out of the range of operation, thus ensuring the signals will be normally mid-scale and no null will occur in the normal operating region.

A-4. Adder and Impedance Matching Amplifier

The basic adder amplifier circuit, shown in figure A-2, is a three-stage, direct-coupled amplifier. The first two stages are complementary common emitter stages, and the last stage is an emitter follower that provides a low output impedance. The open loop voltage gain of this amplifier is about 30 dB.

The most important application of this amplifier is as a summing amplifier, as shown in figure A-3. As a summing amplifier, up to five signals from the sensors (each at a different frequency) can be combined. Since most of the sensor pickoffs have an output impedance of about 2000 ohms, the 215K summing resistors are used to limit pickoff loading to a value small enough to keep within the desired 1% accuracy. The 4.64K shunt resistor, shown connected between ground and the amplifier input, serves to isolate the various signals from each other. Such a summing arrangement cuts the voltage level of the signals by a ratio of about 50.

The adder amplifier output impedance is less than 100 ohms. This low output impedance is desired, since the adder amplifiers in the fish have to transmit the summed signals through 600 feet of tow cable. Because the cable drives the high

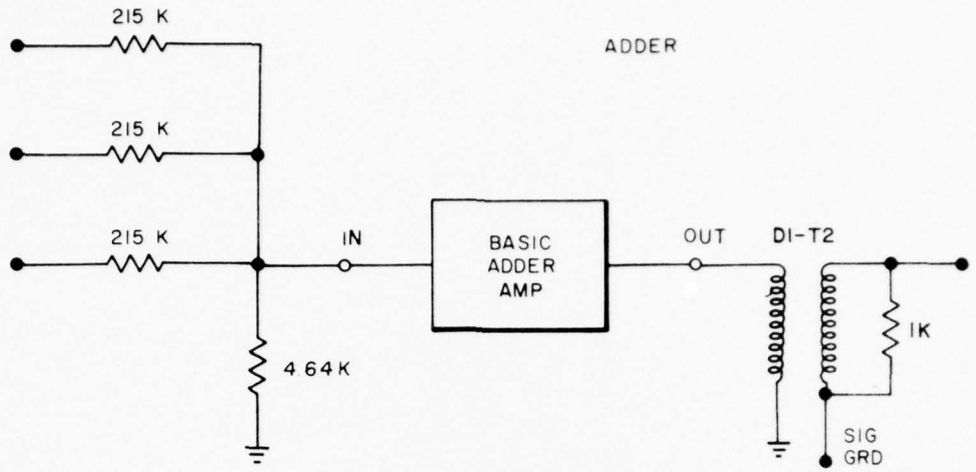


A-5

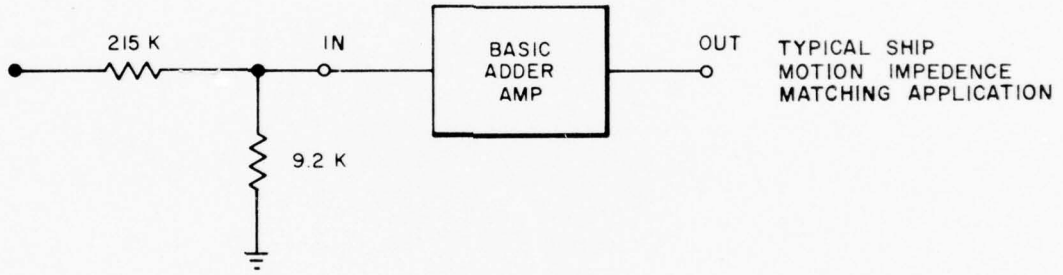
R_{fb} (100K, FISH; 18K, CE Pkg.)
SELECTED TO PROVIDE AN OVERALL SINGLE INPUT GAIN OF 0.7 (Voltage Ratio)

MAXIMUM INPUTS TO A, B, & C ARE 0.67 V A.C. EACH. IN FISH, 0.50 VAC IN CENTRAL ELECTRONICS.

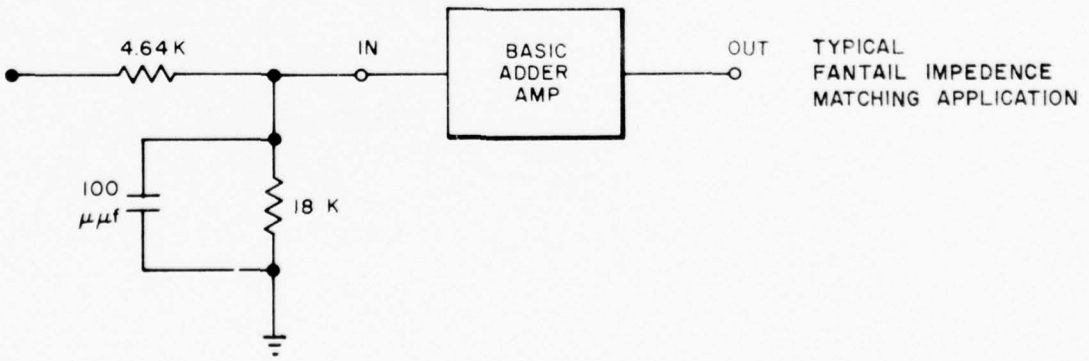
FIGURE A.2.- TYPICAL ADDER



(A)



(B)



(C)

Fig. A-3 - APPLICATIONS OF ADDER AMPLIFIER

impedance resistive dividers, voltage drop is minimized. The low impedance of these signal leads also serves to reduce cross coupling and noise. The overall voltage gain of the fish adder amplifiers are individually adjusted to a value of 0.75 by means of the feedback resistor R_{fb}. The gain of this amplifier proves to be constant within 1% over the temperature range of 20°C to 85°C. The amplifier is decoupled from the power source to prevent cross coupling of the adders through the common power source. Since this same basic amplifier is used for a matching amplifier, a modular construction concept was adopted; all basic amplifiers are built alike and the input and output circuitry is modified as required.

This same basic amplifier is used in the Fantail and Ship Motion Packages to match remote sensor signals to their cables. In this application, the amplifier serves to transform the 2000 ohm output impedance of the transducer pickoff down to an impedance of less than 100 ohms. This low impedance is desirable in that it will reduce coupling between adjacent signals in the same cable.

A-5. Bandpass Filter

In order to recover the signals for single channel recording, the added signals are passed through bandpass filters. These filters are White Instrument Laboratories Type BP2D-5%. The significant characteristics are as follows: bandwidth at 3 dB points, 5% of center frequency; signal source impedance, 100 ohms; filter load impedance, 100K; voltage ratio step-up, 2:1; separation of adjacent system frequency signals, 40 dB. The inputs of the filters are connected in parallel across the adder amplifier output.

A-6. Detector Circuit

The bandpass filters separate the signals, but the sensor information still must be demodulated; i.e., detected. A simple half-wave detector circuit is adequate since all signals are monopolar. The circuit consists of a series 1N100 germanium diode, followed by shunt-parallel combination of a 100K resistor and a 0.33 uf capacitor, which is connected to the bandpass filter output. The diode rectifies the signal, while the forward diode resistance and the capacitor serve as an integrator, smoothing the detected variations into a replica of the original dc sensor signal. The 100K resistor is required for proper filter operation. The Sanborn strip chart has an input impedance of greater than one megohm, and thus any loading due to the recorder is negligible. The detector circuit has a linear range of about 30 dB for a full-scale output of about 9 vdc.

A-7. Fish Relative Angle (or Motion) Sensors

Hermetically sealed potentiometers are used for measuring the relative angle between the tow staff and the fish, and also between the pendulously supported sonar transducer and the fish. Two types of sensors are used —the choice between them being a matter of convenience of hookup and available space. One type consists of a single-turn potentiometer housed in a 2-3/4" diameter by 4-1/4" long stainless steel cylinder. The shaft extends through an O-ring seal and electrical connection is made through a Marsh & Marine connector.

The second type of angle sensor is a small one-turn potentiometer encapsulated in epoxy potting compound. The

total unit is approximately 1" in diameter and 1-1/4" long Again an O-ring seal is used for the shaft which penetrates a brass cylinder. Electrical connection is made with a Marsh & Marine cable, one end of which is encapsulated with the potentiometer.

Either a direct coupling or a linkage is used to couple the motions to the sensors.

A-8. Tow Point Cable Angle Sensor

To determine the tow cable angle, a special package has been constructed by TRACOR that is capable of measuring displacements of a point of the tow cable which allows calculation of the desired angles. A spring-loaded drum capable of eight revolutions is used, with its axis being connected to the shaft of a potentiometer. Pulleys guide a cable from the drum to the carriage used to hold the fish; the carriage serving as a reference. The equipment is "zeroed" with the ship stopped, or at low speeds, and the tow cable hanging vertically. As the tow angle increases, as with increased ship speed and kiting, the sensor cable is payed out causing potentiometer variation. As the two angles decrease, the spring-loaded drum takes up the cable slack, and the potentiometer rotation is reversed.

A-9. Tow Point Cable Tension Sensor

The two point cable tension is obtained by means of a load cells, manufactured by Balwin-Lima-Hamilton Corporation. Two are available —one with the range specified as 0-50,000 pounds, and a second with a specified range of 0-10,000 pounds. The load cells have been used in two different arrangements to obtain cable tension. One arrangement consists of tying

one end of the load cell to the deck of the ship, and the other end of the load cell to the winch drum flange with suitable cables. The other arrangement consists of tying one end of the load cell to the hoist platform and the other end to the tow cable with cable grips, to prevent damage to the tow cable.

A-10. Main Fish Electronics Container

Since the fish is free-flooding, a separate instrument package is employed that consists of watertight container with suitable mounting brackets and connectors for electrical cables, as shown in figure A-4. The container consists of a circular base plate 12-1/4" in diameter, and a mating hat-shaped cover 14-1/2" tall with an O-ring seal. Bulkhead connectors penetrate the base plate for electrical connection to the instruments. All instruments are mounted to a frame that is rigidly attached to the base plate. The package is attached to the test body by mounting brackets on the front and top side of the hat section. The four bulkhead connectors on the base plate are used for the following purposes:

a. A 36-pin connector joins the tow cable to the Fish Instrument Package.

b. A 36-pin connector connects various sensors located in the sonar transducer through the Fish Instrument Package to the tow cable. (No sonar transducers elements are connected.)

c. Two 12-pin connectors connect to other sensors located external to the Fish Instrument Package.

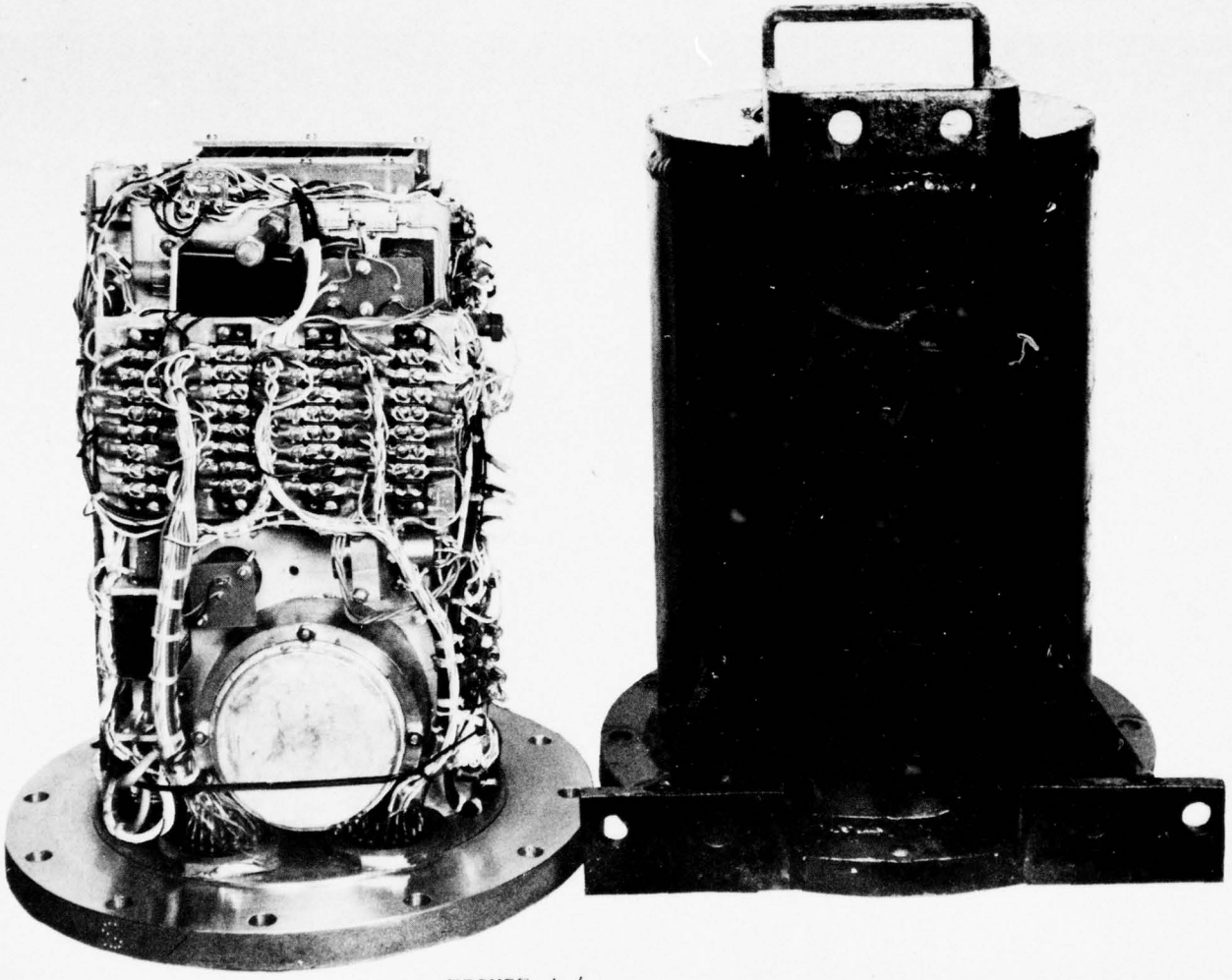


FIGURE A.4

FISH INSTRUMENT PACKAGE

AND PRESSURE COVER

Suitable underwater cables with appropriate connectors are specially made for each cable towed transducer group tested.

A-11. Differential DC Amplifier

Three Burr Brown Model 1505 differential dc amplifiers amplify and isolate the strain gage outputs. These amplifiers are specified to have a 1-megohm input impedance, a voltage gain of 10 to 1000, and no more than a 1% variation in frequency response from dc to 10 kc. Each unit requires a power source of $\pm$15 vdc at 8 ma, with 0.1% regulation.

A-12. Depth Potentiometer

To measure the fish depth, a pressure potentiometer, Giannini Mode 46129, with a range of 0-400 psig, is used. It is mounted to the interior wall of the fish in a sealed container approximately 4" in diameter by 3" long. Water pressure on a diaphragm, which protrudes through the container wall, moves fluid in a Bourdon tube proportional to the diaphragm movement, and hence to the water pressure, or depth, which in turn moves the slide arm of the potentiometer, changing the output resistance. Electrical connections to the main container, (A-10), are made by watertight fittings manufacture by Marsh & Marine Manufacturing Company.

A-13. Fish Pillow-Block Strain Gages

Cable tension at the pillow block on the fish is determined by means of very sophisticated strain gaged pillow blocks, interchangeable with the standard units, which are provided by Brewer Engineering Laboratories. The gages were arranged and connected to provide two separate outputs for components 45^{o} to the horizontal but mutually perpendicular. Electrical connections are made with Marsh & Marine cables.

A-14. Linear Accelerometers

Servonic Instruments (now Gulton Industries) Model 111 accelerometers are used, which have a scale range of ±1 g and output linearity within 1% of full scale. The accelerometers use a variable differential transformer with a resonant frequency of approximately 20 c/s as the output pickoff. Six accelerometers of this type are used in the system; i.e., a vertical, horizontal, and fore-and-aft package is located both in the fish and at the fantail. An additional ±5 g accelerometer, Model TLW, is an optional sensor sometimes used to measure the vertical acceleration of the fish when a greater range is desired.

A-15. Yaw Rate Gyro

A Model C70 2021 001 yaw rate gyro with a synchro type pickoff was purchased from the Kearfott Division of General Precision, Inc. This gyro is a standard unit that has a resonant frequency of about 15 c/s, and a full-scale range of $\pm 20^{\circ}$/sec, with a threshold of less than 0.01°/sec and linearity of 2% of full scale. The gyro spin motor consumes 4 watts of 26 vac, 400 c/s, 3 phase.

A-16. Vertical Gyro

The vertical gyro used in the fish instrumentation is a Minneapolis-Honeywell Model GG-99C5 electrically driven, two-axis displacement gyro, equipped with gravity sensing mercury accelerometers and an erection system that erects to within $1/8^{\circ}$ of the local vertical. Potentiometer outputs are used on the roll and pitch axes with pitch limits of $\pm 85^{\circ}$ and roll limits of $\pm 178^{\circ}$. The gyro spin motor consumes a maximum of 20 watts at 115 vac, 400 c/s.

A-17. Synchro Repeater

The synchros used to couple potentiometers to the outputs of the ship's master gyro are the standard model, "Size 5F," manufactured by Arma.

A-18. Power Supplies

Three Technipower, Inc., direct-current power supplies are used with the system: one, with an output at 28 vdc at 3.0 amperes and 0.05% voltage regulation, supplies power for the Central Electronics and Ship Motion Package; another furnishes 26 vdc at 4.0 amperes with 0.5% regulation to the fantail, fish, and electronics; and a third, a 28 vdc supply located in the Ship Motion Package, is held as a spare. An 80 dvc supply was constructed ty TRACOR and is described in the Central Electronics Package section.

A-19. Super-Regulator

Super-Reg zener diodes, made by Trio Laboratories, Inc., are utilized. They consist of a regulating circuit mounted in a hermetically sealed TO-36 case. The exact desired zener voltage is adjustable over $\pm$10% of the nominal voltage by means of external resistors. Each unit is specified to dissipate 75 watts at 25^{o}C, with the dissipation linearly decaying to 37.5 watts at 100^{o}C.

A-20. Inverter

A Sorensen Model DQIS 28/115-.35 inverter is used in the fish to drive the gyro spin motors. With an input of 26-30 vdc, the unit is capable of deliviring 115 vac, 400 c/s, at approximately 50 watts. The vertical gyro is driven directly, but a transformer is necessary to step the voltage

down to 26 vac for the yaw rate gyro. This 26 vac is also rectified, filtered, and regulated by a Super-Reg (A-19) to -15 vdc for the Burr Brown amplifiers (A-11).

A-21. Magnetic Tape Recorder

The magnetic tape recorder used is an Ampex Model FR-1300 that is equipped with record and playback electronics for seven FM channels. Six FM channels are used for data channel recording, while one is to record unmodulated oscillator signals, voice comments, and time marks.

A-22. Paper Chart Recorder

A Sanborn Model 850, eight-channel recorder is used to record demodulated data from eight data channels. The recorder is equipped with Model 850-1000 preamps for recording the direct current signals.

APPENDIX B

PARTS LIST AND SUBASSEMBLIES

FISH INSTRUMENT PACKAGE

6		A_1 thru A_6 Adders
	3	RN60D2153F Resistor 21KΩ ¼w 1%
	1	RN60D4641F Resistor 4.64KΩ ¼w 1%
	1	RC07GF153K Resistor 15KΩ ¼w 10%
	1	RC07GF183K Resistor 18KΩ ¼w 10%
	1	RC07GF273K Resistor 27KΩ ¼w 10%
	2	RC07GF332K Resistor 3.3KΩ ¼w 10%
	1	RC07GF561K Resistor 560Ω ¼w 10%
	1	RC07GF272K Resistor 2.7Ω ¼w 10%
	1	RC07GF562K Resistor 5.6KΩ ¼w 10%
	1	RC20GF470K Resistor 47Ω ½w 10%
	2	SCM106BP020A4 Tantalytic Capacitor 10μf 35v (TI)
	2	SCM105FP020A4 Tantalytic Capacitor 1μf 35v (TI)
	1	CS13AF3RK Tantalytic Capacitor 3.3μf 35v
	1	CS13AF220K Tantalytic Capacitor 22μf 35v
	2	2N2270 Transistor
	1	2N1305 Transistor
	1	DI-T2 Transformer (UTC)
3		XTV400C Tantalytic Capacitor 500μf 40v
2		MO-.1 Inductor (UTC)
2		A_7 & A_8 Burr Brown Board
	1	1505 Differential Amplifier (Burr Brown)
	1	RC07GF470K Resistor 47Ω ¼w
	2	RC07GF102K Resistor 1KΩ ¼w*
	1	RC07GF104K Resistor 100KΩ ¼w
	1	Wirewound Multi-turn Potentiometer 100Ω ¼w
	1	Carbon Multi-turn Potentiometer 200KΩ ¼w
1		Model S200 Oscillator 560 cps (Solid State Electronics)

* Nominal value. Adjust gain and may vary with installation.

Fish Instrument Package (cont.)

1 Model S200 Oscillator 730 cps (Solid State Electronics)
1 Model S200 Oscillator 960 cps (Solid State Electronics)
10 8-140 Terminal Strips (Cinch Jones)
2 RH-5 Resistor 10Ω 5w
1 Model DQ1S 28/115-.35 Sine Wave Inverter (Sorenson)
1 A_9 Power Distribution Board
- 1 109D686X0060T2 Tantalytic Capacitor 68μf 60v (Sprague)
- 2 CS13AF470K Tantalytic Capacitor 47μf 35v
- 2 RC42GF151K Resistor 150Ω 2w 10%
- 1 RC42GF181K Resistor 180Ω 2w 10%
- 4 1N96A Diode
- 1 RC20GF822K Resistor 8.2KΩ ½w 10%
- 1 RC20GF923K Resistor 82KΩ ½w 10%
- 11 279000 Pigtail Fuse .3 amp (Little Fuse)

3 A_{10} thru A_{12} Amplifiers
- 2 RC07GF183K Resistor 18KΩ ¼w 10%
- 1 RC07GF103K Resistor 10KΩ ¼w 10%
- 1 RC07GF682K Resistor 6.8Ω ¼w 10%
- 1 RC07GF152K Resistor 1.5KΩ ¼w 10%
- 2 RC07GF102K Resistor 1KΩ ¼w 10%
- 1 RC07GF391K Resistor 390Ω ¼w 10%
- 1 RC07GF22oK Resistor 22Ω ¼w 10%
- 1 RC20GF470K Resistor 47Ω ½w 10%
- 1 RC20GF333K Resistor 33Ω ½w 10%
- 4 2N2270 Transistor
- 1 2N1305 Transistor
- 3 1N96A Diode
- 1 1N461 Diode
- 2 SCM476HP035A2 Tantalytic Capacitor 47μf 35v (TI)
- 2 SCM105FP035A2 Tantalytic Capacitor 1μf 35v (TI)

1	SCM224FP035A2 Tantalytic Capacitor .22μf 35 v
1	DGG99C5 Vertical Gyro (Honeywell)
1	C702021-002 Rate Gyro (Kearfott)
2	75TE15A Super-Reg (TRIO)
2	111-H10 Accelerometer (Servonics)
1	111-V10 Accelerometer (Servonics)
1	TF4SX01EA Transformer (Stancor)
1	A_{13} Divider Board (LTB"A")
3	RC07GF274K Resistor 270KΩ ¼w 10%
2	RC07GF473K Resistor 47KΩ ¼w 10%
1	RC07GF474K Resistor 470KΩ ¼w 10%
1	RC07GF184K Resistor 180KΩ ¼w 10%
1	RC07GF684K Resistor 680KΩ ¼w 10%
4	RN60D2154F Resistor 215KΩ ¼w 1%
2	RN60D3092F Resistor 30.9KΩ ¼w 1%
1	RN60D1962F Resistor 19.6KΩ ¼w 1%
1	A_{14} Divider Board (LTB"B")
3	RN60D2671F Resistor 2.67KΩ ¼w 1%
6	RN60D1330F Resistor 133Ω ¼w 1%
3	RN60D33R2F Resistor 33.2Ω ¼w 1%
3	DO-T36 Transformer (UTC)
1	19A11/3 Fan (Globe)
1	RC07GF222K Resistor 2.2KΩ ¼w 10%
1	RC07GF392K Resistor 3.9KΩ ¼w 10%
1	RC07GF273K Resistor 27KΩ ¼w 10%
1	RC07GF152K Resistor 1.5KΩ ¼w 10%
1	RN60D2871F Resistor 2.87KΩ ¼w 1%
1	RC20GF121K Resistor 120Ω ½w 10%
1	RC20GF821K Resistor 820Ω ½w 10%
1	RC07GF103K Resistor 10KΩ ¼w 10%
1	RC07GF183K Resistor 18KΩ ¼w 10%
1	SCM224FP035A2 Tantalytic Capacitor .22μf 35v (TI)

Fish Instrument Package Contd.

2	XSO-36-BCR 36 Pin Connector (Marsh & Marine)
2	XSO-12-BCR 12 Pin Connector (Marsh & Marine)

Fish Instrument Package Contd.

2	XSO-36-BCR 36 Pin Connector (Marsh & Marine)
2	XSO-12-BCR 12 Pin Connector (Marsh & Marine)

FANTAIL ACCELEROMETER PACKAGE

1 Cabinet 12" x 6 " x 7" D (Bud)
- 2 AN/MS 18-1S Bulkhead Receptical 10 Pin Female (Amphenol)
- 2 AN/MS 18-11P Bulkhead Receptical 5 Pin Male (Amphenol)
- 1 HC5005A Capacitor 500μf 50v (Mallory)
- 1 21-540 Terminal Board - 21 Pin (Cinch Jones)
- 6 A_1 thru A_6 Adder
  - 3 RN60D2153F Resistor 215KΩ ¼w 1%
  - 1 RN60D4641F Resistor 4.64KΩ ¼w 1%
  - 1 RC07GF153K Resistor 15KΩ ¼w 10%
  - 1 RC07GF183K Resistor 18KΩ ¼w 10%
  - 1 RC07GF273K Resistor 27KΩ ¼w 10%
  - 2 RC07GF332K Resistor 3.3KΩ ¼w 10%
  - 1 RC07GF272K Resistor 2.7KΩ ¼w 10%
  - 1 RC07GF562K Resistor 5.6KΩ ¼w 10%
  - 1 RC20GF470K Resistor 47Ω ¼w 10%
  - 2 2N2270 Transistor
  - 1 2N1305 Transistor
  - 2 SCM105FP035A2 Tantalytic Capacitor 1μf 35v (TI)
  - 1 SCM335BP035A2 Tantalytic Capacitor 3.3μf 35v (TI)
  - 2 SCM106GP020A2 Tantalytic Capacitor 10μf 20v (TI)
  - 1 CS13AF220K Tantalytic Capacitor 22μf 35v (TI)
- 1 A_7 Amplifier
  - 2 RC07GF183K Resistor 18KΩ ¼w 10%
  - 1 RC07GF104K Resistor 100KΩ ¼w 10%
  - 1 RC07GF682K Resistor 6.8KΩ ¼w 10%
  - 1 RC07GF152K Resistor 1.5KΩ ¼w 10%
  - 2 RC07GF102K Resistor 1KΩ ¼w 10%
  - 1 RC07GF220K Resistor 22Ω ¼w 10%

Fantail Accelerometer Package (Contd.)

	1	RC20GF101K Resistor 100Ω ½w 10%
	1	RC20GF470K Resistor 47Ω ½w 10%
	1	RC07GF391K Resistor 390Ω ¼w 10%
	1	RC20GF33K Resistor 33KΩ ½w 10%
	4	2N2270 Transistor
	1	2N1305 Transistor
	3	1N9118 Diode
	1	1N461 Diode
	2	SCM476HP035A2 Tantalytic Capacitor 47μf 35v (TI)
	2	SCM105FP035A2 Tantalytic Capacitor 1μf (TI)
	1	DM15B221K Capacitor Dipped Mica 220pf
	1	SCM224FP035A2 Tantalytic Capacitor (TI)
1	A_8	Burr Brown 1505
	2	RC20GF103K Resistor 100KΩ ½w 10%
	2	RC20GF470K Resistor 47Ω ½w 10%
	2	RC20GF221K Resistor 220Ω ½w 10%
1	A_9	Power Distribution Board
	3	RC32GF331K Resistor 330Ω 1w 10%
	2	RC20GF470K Resistor 47Ω ½w 10%
	2	RC42GF120K Resistor 12Ω 2w 10%
	3	SCM476HP035A2 Tantalytic Capacitor 47μf 35v (TI)
	1	CS13AF220K Tantalytic Capacitor 22μf 35v
	4	1N96A Diode
	2	1N461 Diode
2		75TE15A Super-Reg (TRIO)
1		75TE33 Super-Reg (TRIO)
4		FB100B Heat Sinks
1		Model S200 Oscillator 1300 c/s (Solid State Electronics)
2		111-H10 Accelerometer (Servonics)
1		111-V10 Accelerometer (Servonics)

36 VDC POWER SUPPLY

1 Cabinet (WA1541) (Bud)

- 1 Power Supply M38.0-6.0 (Technipower)
- 1 RE-147 Muffin Fan (Roton)
- 1 KB17DG Relay (Potter Brumfield)
- 1 6325 Elapsed Time Meter (Cramer)
- 1 AN 3102-18-1S Panel Mounting Receptical 10 Pin Female (Amphenol)
- 2 HLK Fuse Holder (Buss)
- 1 0147 Rheostat 25Ω 25w (Ohmite)
- 1 61M10 AC Socket Male 3 Prong (Amphenol)

SHIP MOTION PACKAGE

1 Box 11" x 19" x 9½"

- 1 Panel Mount Receptical AC Male 3 Prong
- 2 AN/MS 18-1S Panel Mount Receptical 1 Open Female (Amphenol)
- 1 Switch (SPST)
- 1 Fuseholder HLK (Buss)
- 1 Fuse 3AG ½ amp.
- 1 75C-431 Lamp Holder w/Red Lens (Dialco)
- 1 6S6 Lamp 6w 120v
- 3 AN/MS 18-11P Panel Mount Receptical 5 Pin Male (Amphenol)
- 4 AN/MS 9760-18 Cap (Amphenol)
- 1 RE 148 Whisper Fan (Roton)
- 4 5F Synchro Repeater (Arma)
- 1 S1G 1171 Potentiometer 20KΩ 5% (Helipot)
- 1 S1G 1172 Potentiometer 20KΩ 5T (Helipot)
- 2 G Potentiometer 5KΩ 5% Tapped (Helipot)
- 1 A_1 Decoupling Board
  - 1 MO-1 Filter Inductor (UTC)
  - 1 RC20GF680F Resistor 68Ω ½w 10%
  - 1 1N178 Diode
  - 1 CS13AF226K Tantalytic Capacitor 22μf 35v
- 4 A_2 thru A_5 Adders
  - 3 RN60D2153F Resistor 215KΩ ¼w 1%
  - 1 RC60D4641F Resistor 4.64KΩ ¼w 1%
  - 1 RC07GF153K Resistor 15KΩ ¼w 10%
  - 1 RC07GF183K Resistor 18KΩ ¼w 10%
  - 1 RC07GF273K Resistor 27KΩ ¼w 10%
  - 2 RC07GF332K Resistor 3.3KΩ ¼w 10%
  - 1 RC07GF561K Resistor 560KΩ ¼w 10%
  - 1 RC07GF272K Resistor 2.7KΩ ¼w 10%
  - 1 RC20GF562K Resistor 5.6KΩ ¼w 10%

Ship Motion Package (Contd.)

1	RC20GF470K Resistor 47Ω ½w 10%
2	SCM106BP020A4 Tantalytic Capacitor 10μf 20v 20% (TI)
2	SCM105FP020A4 Tantalytic Capacitor 1μf 20v 20% (TI)
1	CS13AF335K Tantalytic Capacitor 3.3μf 35v
1	CS13AF226K Tantalytic Capacitor 22μf 35v
2	2N2270 Transistor
1	2N1305 Transistor
1	DI-T36 Transformer (UTC)
1	A_6 Amplifier
2	RC07GF183K Resistor 18KΩ ¼w 10%
1	RC07GF103K Resistor 10KΩ ¼w 10%
1	RC07GF682K Resistor 6.8KΩ ¼w 10%
1	RC07GF152K Resistor 1.5KΩ ¼w 10%
2	RC07GF102K Resistor 1KΩ ¼w 10%
1	RC07GF391K Resistor 390Ω ¼w 10%
1	RC07GF220K Resistor 22Ω ¼w 10%
1	RC20GF470K Resistor 47Ω ½w 10%
4	2N2270 Transistor
1	2N1305 Transistor
3	1N96A Diode
1	1N461 Diode
2	SCM476HP035A2 Tantalytic Capacitory 47μf 35v (TI)
2	SCM105FP035A2 Tantalytic Capacitor 1μf 35v (TI)
1	DM15B221K Dipped Mica Capacitor 220 pf
1	CS13AF224K Tantalytic Capacitor .22μf 35v
4	5-540 Terminal Boards 5 Pin (Cinch Jones)
1	10-540 Terminal Boards 10 Pin (Cinch Jones)
1	Model M 28.0-.075A Power Supply (Technipower)
1	Model S200 Oscillator 1700 c/s (Solid State Electronics)

CENTRAL ELECTRONICS PACKAGE

1	26-4301-85 Blue Ribbon Connector (Amphenol)
1	26-4301-24S Blue Ribbon Connector (Amphenol)
5	AN3102-18-11S Connector 5 pin (Amphenol)
1	AN3102-18-10S Connector 4 pin
32	UG254A/U Coax connectors
1	Speaker 4 inch 4Ω
2	No. 276 Telephone jacks (H. H. Smith)
2	CP05A1KC104K Capacitor .1μf 100v
1	CM1B15 Industrial timer
12	M-5S Winchester sockets
5	3D05-5P Snap action push button switch (ACRO)
1	Model 1212 Ammeter 0-100μa (Simpson)
1	RV6LATS101K Potentiometer 100Ω
1	A_1 Microphone Amplifier
3	SCM224FP035A2 Tantalytic Capacitor 22μf 35v (TI)
1	DM15B271K Dipped Mica Capacitor 27 pf
1	DM15B101K Dipped Mica Capacitor 100pf
1	RC20GF473K Resistor 47KΩ ½w 10%
1	RC20GF122K Resistor 1.2KΩ ½w 10%
1	RC20GF822K Resistor 8.2KΩ ½w 10%
1	RC20GF470K Resistor 47Ω ½w 10%
1	RC20GF101K Resistor 100Ω ½w 10%
1	RC20GF124K Resistor 102Ω ½w 10%
1	RC20GF102K Resistor 1KΩ ½w 10%
1	RC20GF332K Resistor 3.3Ω ½w 10%
1	RC20GF152K Resistor 1.5KΩ ½w 10%
3	2N2270 Transistor
9	A_2 thru A_{10} Amplifier
2	RC07GF183K Resistor 18KΩ ¼w 10%
1	RC07GF103K Resistor 10KΩ ¼w 10%

Central Electronics Package (contd.)

9	A_2 thru A_{10} Amplifier (contd.)	
	1	RC07GF682K Resistor 6.8KΩ ¼w 10%
	1	RC07GF152K Resistor 1.5KΩ ¼w 10%
	2	RC07GF102K Resistor 1KΩ ¼w 10%
	1	RC07GF220K Resistor 22Ω ¼w 10%
	1	RC20GF470K Resistor 47Ω ½w 10%
	1	RC20GF333K Resistor 33KΩ ½w 10%
	4	2N2270 Transistor
	1	2N1305 Transistor
	3	1N96A Diode
	1	1N461 Diode
	2	SCM476HP035A2 Tantalytic Capacitor 47µf 35v (TI)
	2	SCM105FP035A2 Tantalytic Capacitor 1µf 35v (TI)
	1	SCM224FP035A2 Tantalytic Capacitor .22µf 35v (TI)
1	A_{11} Marker Amplifier	
	1	CS13AF220K Tantalytic Capacitor 22µf 35v
	2	RC20GF104K Resistor 100KΩ ½w 10%
	2	RC20GF474K Resistor 470KΩ ½w 10%
	1	RC20GF224K Resistor 220KΩ ½w 10%
	1	RC20GF274K Resistor 270KΩ ½w 10%
	1	RC20GF473K Resistor 47KΩ ½w 10%
	2	2N2270 Transistor
2	75C-431 Lamp holder w/red lens	
2	6S6 Lamp 6w 120v	
9	A_{12} thru A_{20} Adders	
	3	RN60D2153F Resistor 215KΩ ¼w 1%
	1	RN60D4641F Resistor 4.64KΩ ¼w 1%
	1	RC07GF153K Resistor 15KΩ ¼w 10%
	1	RC07GF183K Resistor 18KΩ ¼w 10%

Central Electronics Package (contd.)

9	A_{12} thru A_{20} Adders (contd.)	
	1	RCO7GF273K Resistor 27KΩ ¼w 10%
	2	RCO7GF332K Resistor 3.3KΩ ¼w 10%
	1	RCO7GF561K Resistor 560Ω ¼w 10%
	1	RCO7GF272K Resistor 2.7KΩ ¼w 10%
	1	RCO7GF562K Resistor 5.6Ω ¼w 10%
	1	RC20GF470K Resistor 47Ω ½w 10%
	2	SCM106BPO20A4 Tantalytic Capacitor 10µf 35v (TI)
	2	SCM105FPO20A4 Tantalytic Capacitor 1µf 35v (TI)
	1	CS13AF3R3K Tantalytic Capacitor 3.3µf 35v
	1	CS13AF220K Tantalytic Capacitor 22µf
	2	2N2270 Transistor
	1	2N1305 Transistor
1	ST42A Switch (SPST)	
1	ST52K Switch (DPDT)	
1	HKL Fuse holder	
1	3AG Fuse 2 amp	
1	1N96A Diode	
1	SC628 Sonalert (Electropac)	
2	2200B Terminal Board (USECO)	
	2	RCO7GF473K Resistor 47KΩ ¼w 10%
	3	RCO7GF273K Resistor 27KΩ ¼w 10%
	4	RCO7GF123K Resistor 12KΩ ¼w 10%
	3	RCO7GF183K Resistor 18KΩ ¼w 10%
	1	RCO7GF684K Resistor 680KΩ ¼w 10%
	3	RCO7GF153K Resistor 15KΩ ¼w 10%
	1	RCO7GF222K Resistor 2.2KΩ ¼w 10%
	2	RCO7GF274K Resistor 270KΩ ¼w 10%
	4	RCO7GF393K Resistor 39KΩ ¼w 10%
	1	RCO7GF685K Resistor 6.8MΩ ¼w 10%
	1	RCO7GF472K Resistor 4.7KΩ ¼w 10%

Central Electronics Package (contd.)

2	2200B Terminal Board (contd.)
	2 RC07GF823K Resistor 82KΩ ¼w 10%
	6 RC07GF103K Resistor 10KΩ ¼w 10%
	2 RC07GF333K Resistor 33KΩ ¼w 10%
	1 RC07GF392K Resistor 3.9KΩ ¼w 10%
	3 RC07GF152K Resistor 1.5KΩ ¼w 10%
	2 RC07GF182K Resistor 1.8KΩ ¼w 10%
	1 RC07GF151K Resistor 150Ω ¼w 10%
	6 RN60D1471F Resistor 1.47KΩ ¼w 1%
	1 RN60D1330F Resistor 133Ω ¼w 1%
1	250-125-214 Switch (Ledex)
7	BP2D Filter 560 c/s 5% (White)
7	BP2D Filter 730 c/s 5% (White)
7	BP2D Filter 960 c/s 5% (White)
7	BP2D Filter 1300 c/s 5% (White)
7	BP2D Filter 1700 c/s 5% (White)
35	RC20GF104K Resistor 100KΩ ½w 10%
35	1N96A Diode
35	WMF1P33 Capacitor .33μf (Cornell-Dubilier)
1	CPX-7 Relay DPDT (Magnacraft)

CENTRAL POWER SUPPLY

1	S78 Transformer (UTC)
2	HC15010A Capacitor 1000μf 150v (Mallory)
1	M28.0-3.0A Power Supply (Technipower)
2	0149 Rheostat Type H 50Ω 2w 10%
4	1N347 Diode
1	RC42GF101K Resistor 100Ω 2w 10%
1	RC42GF822K Resistor 8.2KΩ 2w 10%
1	VPR-5-F Resistor 1KΩ 5w 10%

APPENDIX C

PACKAGE PHOTOGRAPHS

VDS PHOTO ILLUSTRATION LOG

FIGURE	TITLE
C-1	Fish Instrument Package, Forward View
C-2	Fish Instrument Package, Starboard View
C-3	Fish Instrument Package, Port View
C-4	Fish Instrument Package, Aft View
C-5	Fish Instrument Package, Top View
C-6	Fantail Electronics Package
C-7	Ship Motion Package
C-8	Central Electronics: Sanborn Chart Recorder, Ampex Tape Recorder, and Central Electronics Package
C-9	Central Electronics Package: Top
C-10	Central Electronics Package: Bottom

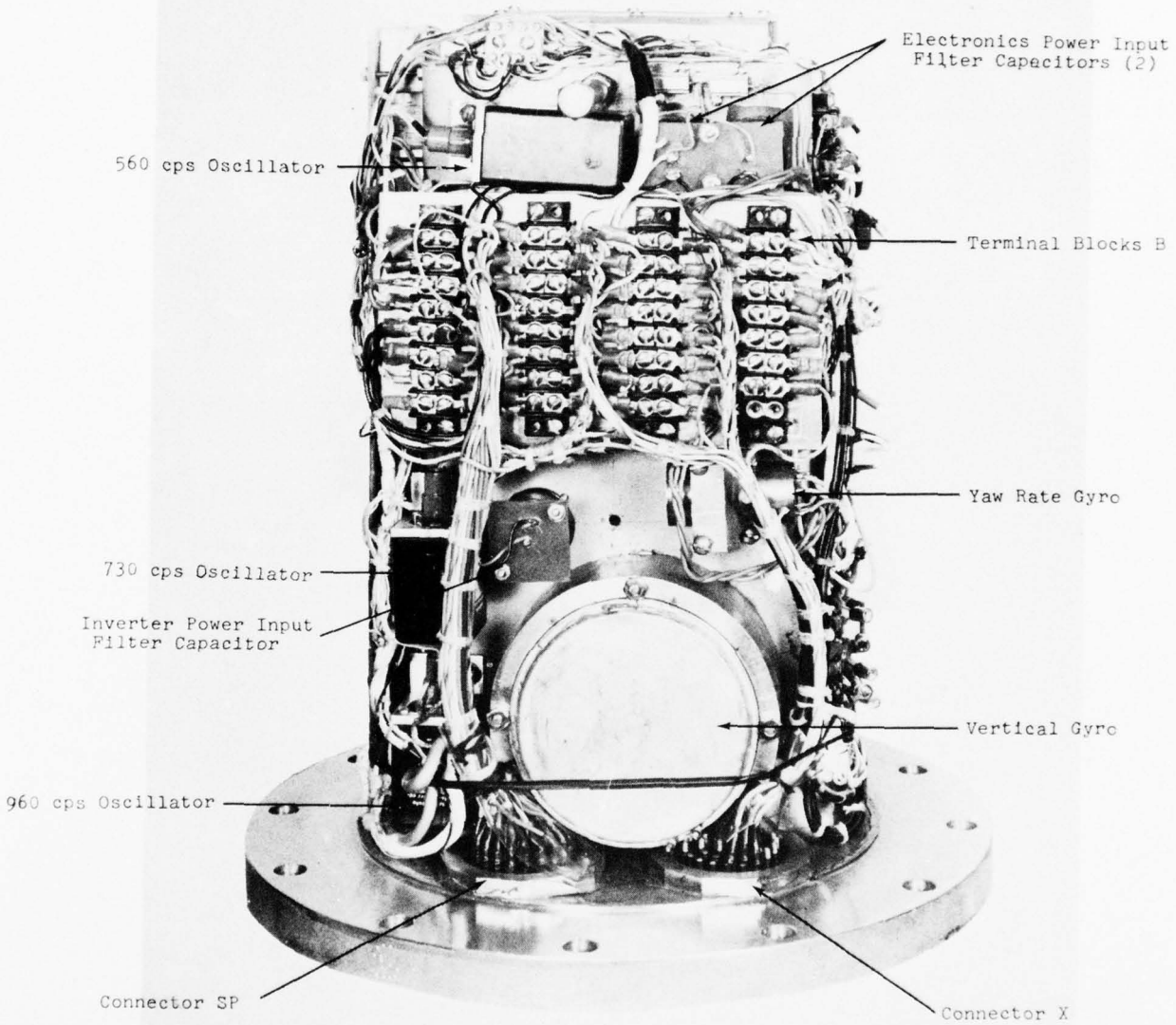


FIGURE C.1

FISH INSTRUMENT PACKAGE:
FORWARD VIEW

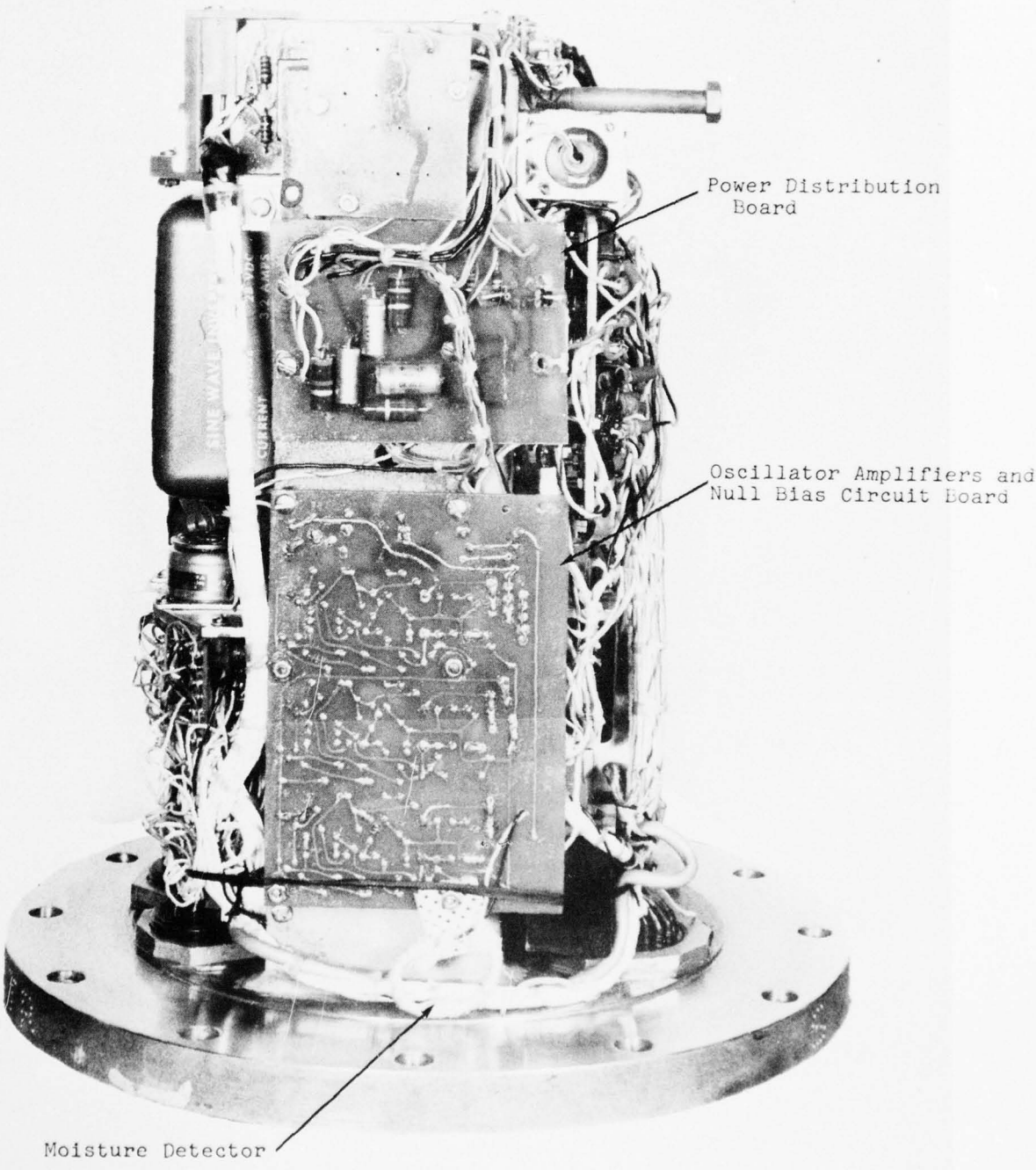


FIGURE C.2

FISH INSTRUMENT PACKAGE:
STARBOARD VIEW

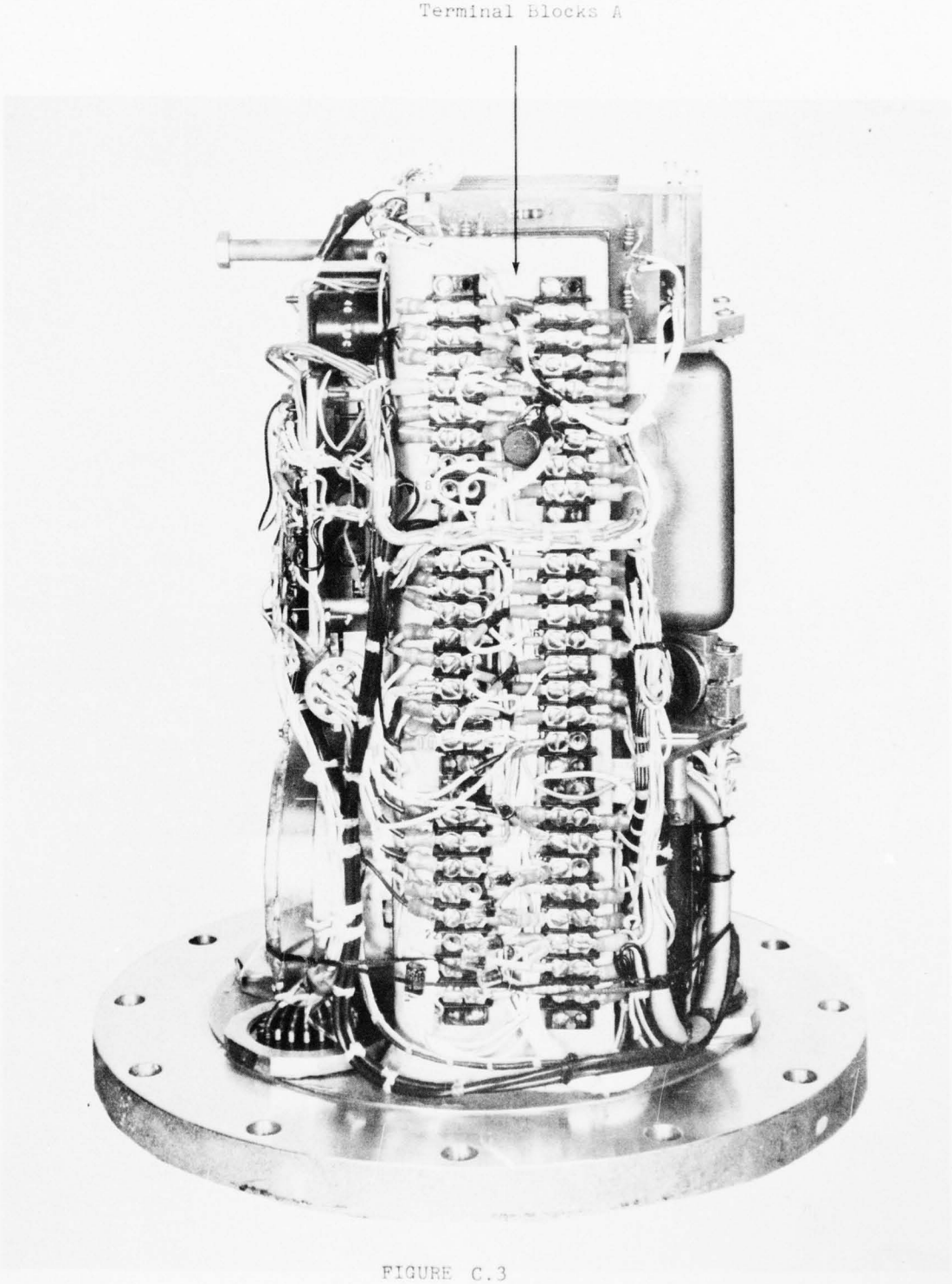


FIGURE C.3

FISH INSTRUMENT PACKAGE:
PORT VIEW

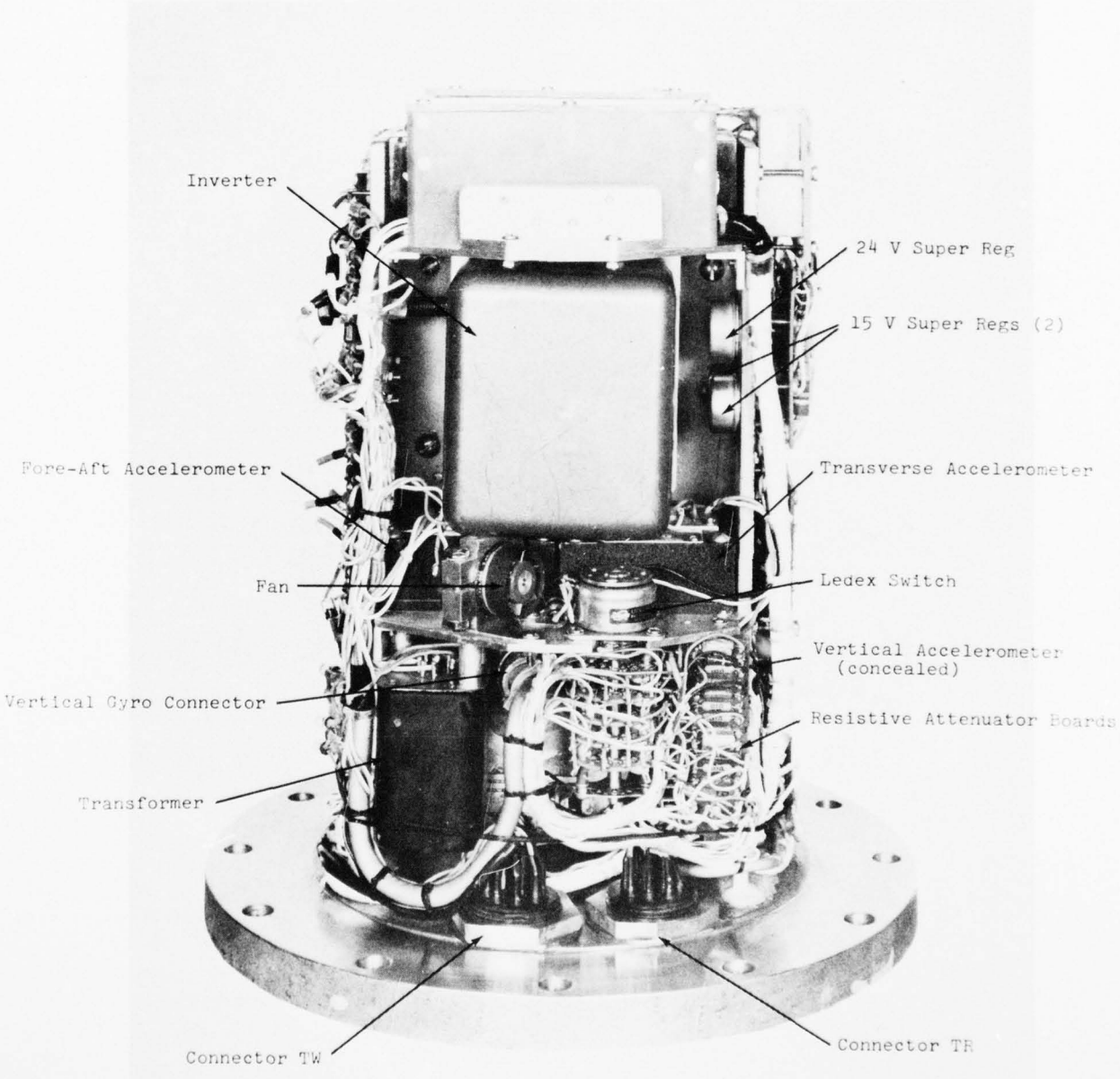


FIGURE C.4

FISH INSTRUMENT AFT VIEW

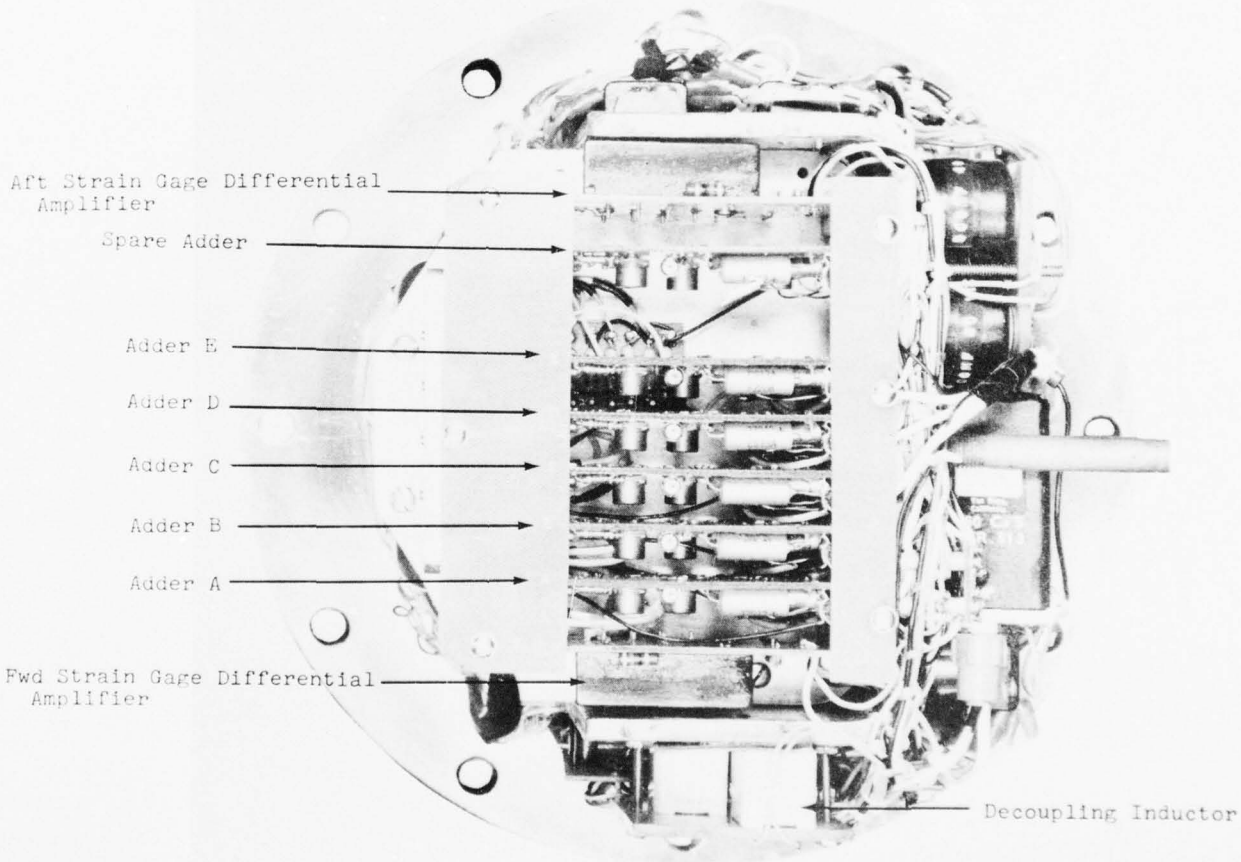


FIGURE C.5
FISH INSTRUMENT PACKAGE:
TOP VIEW

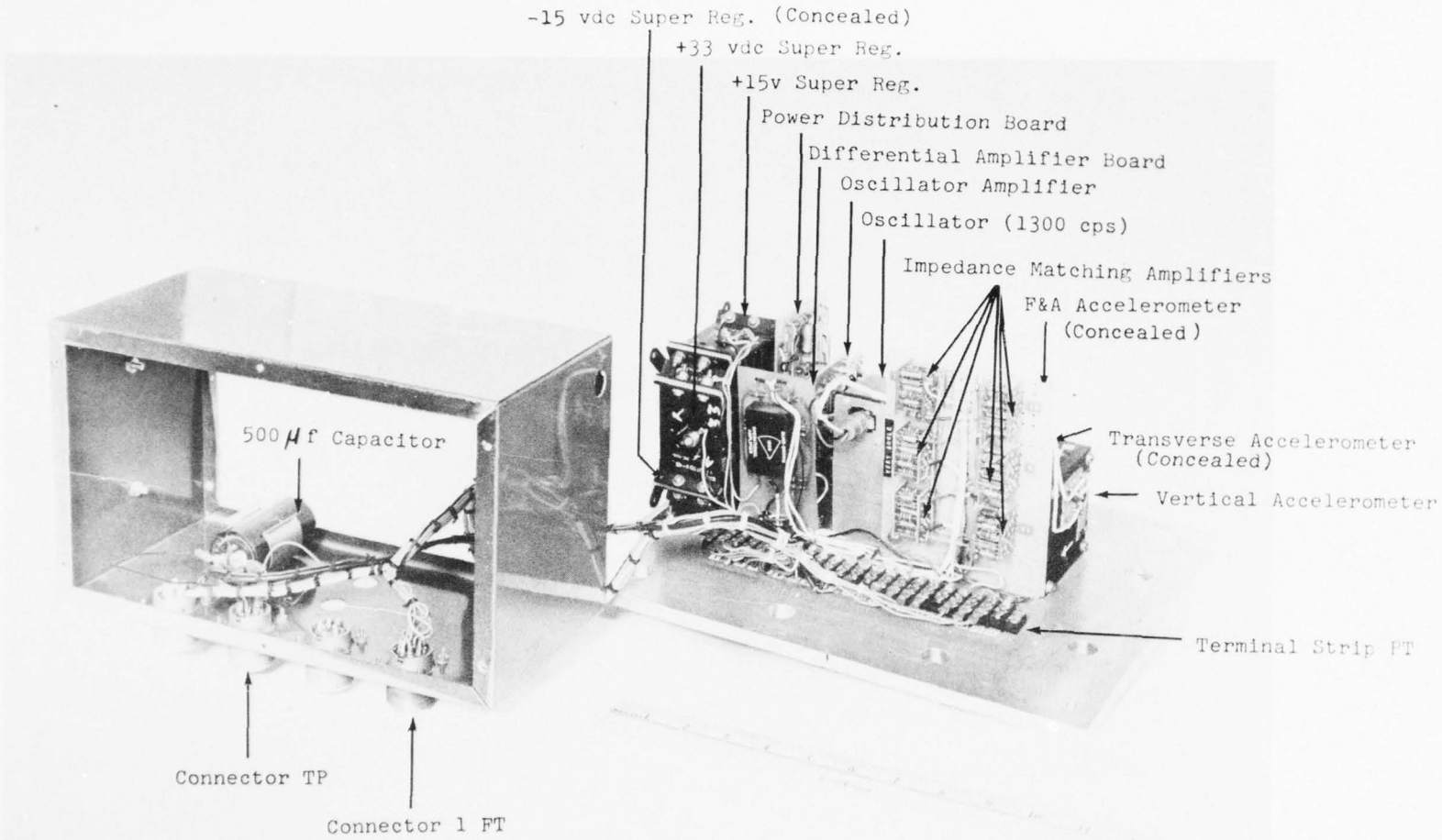


FIGURE C.6

FANTAIL ELECTRONICS PACKAGE

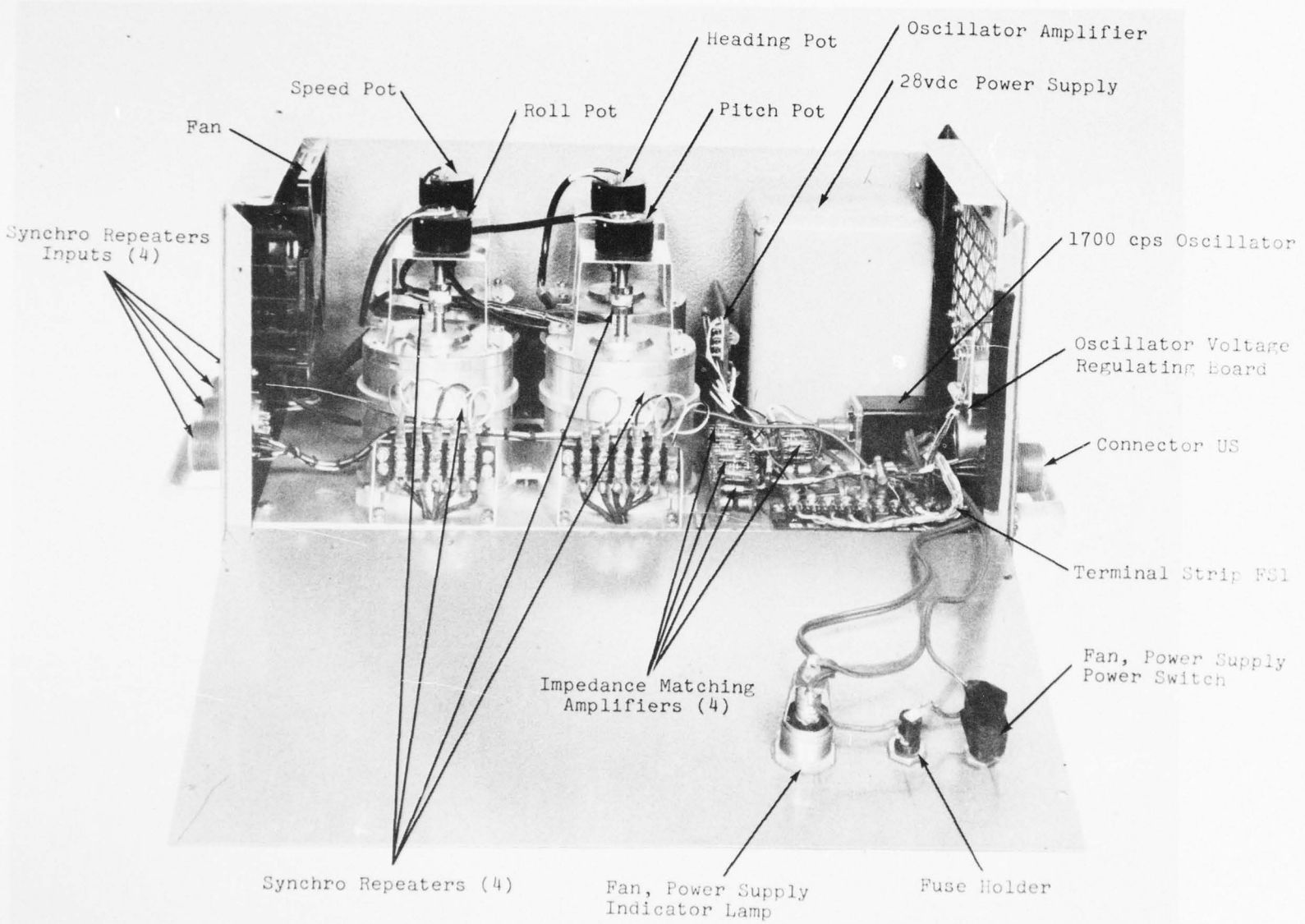


FIGURE C.7
SHIP MOTION PACKAGE

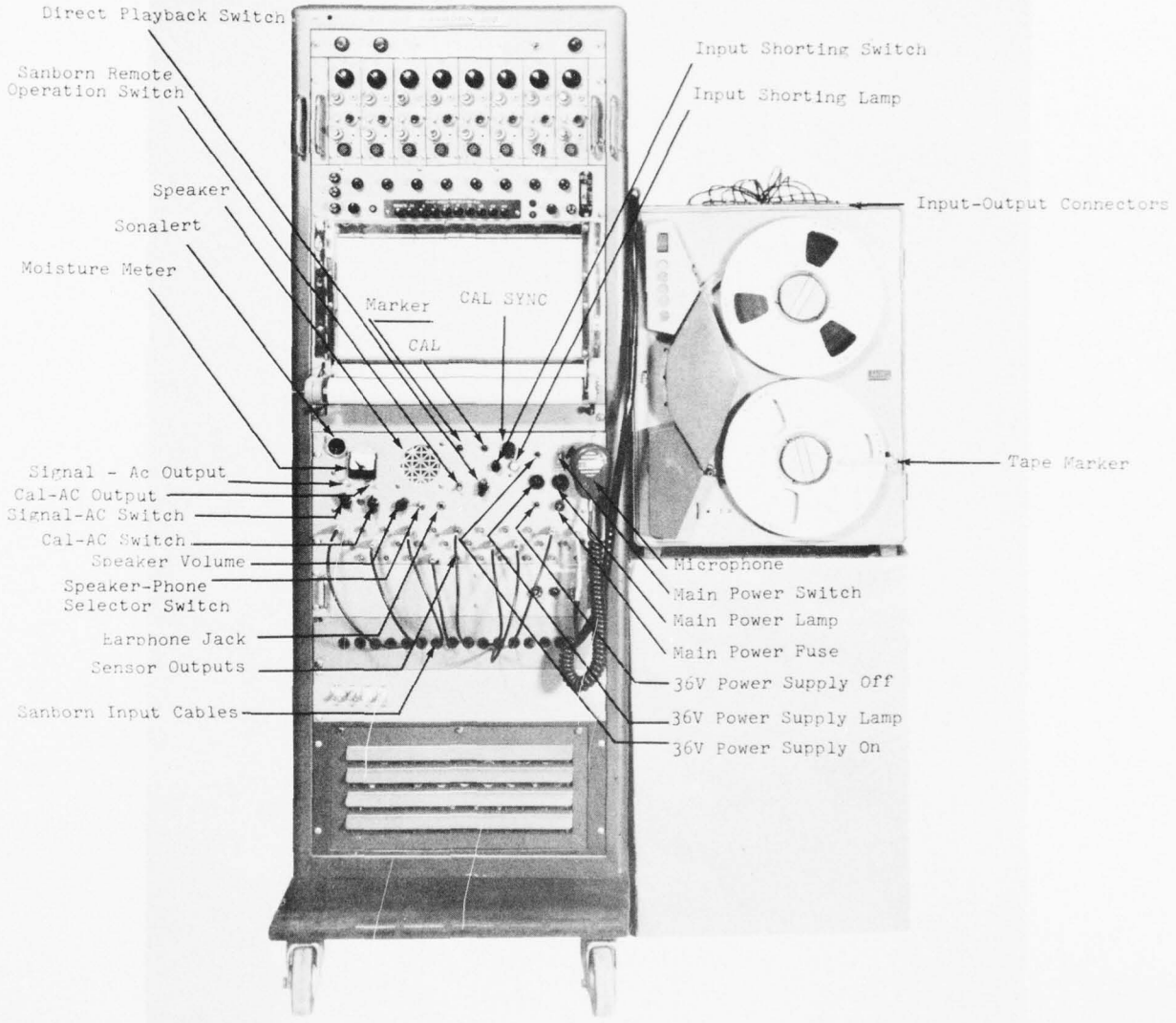


FIGURE C.8

CENTRAL ELECTRONICS:

SANBORN CHART RECORDER, AMPEX TAPE RECORDER & CENTRAL ELECTRONICS PACKAGE

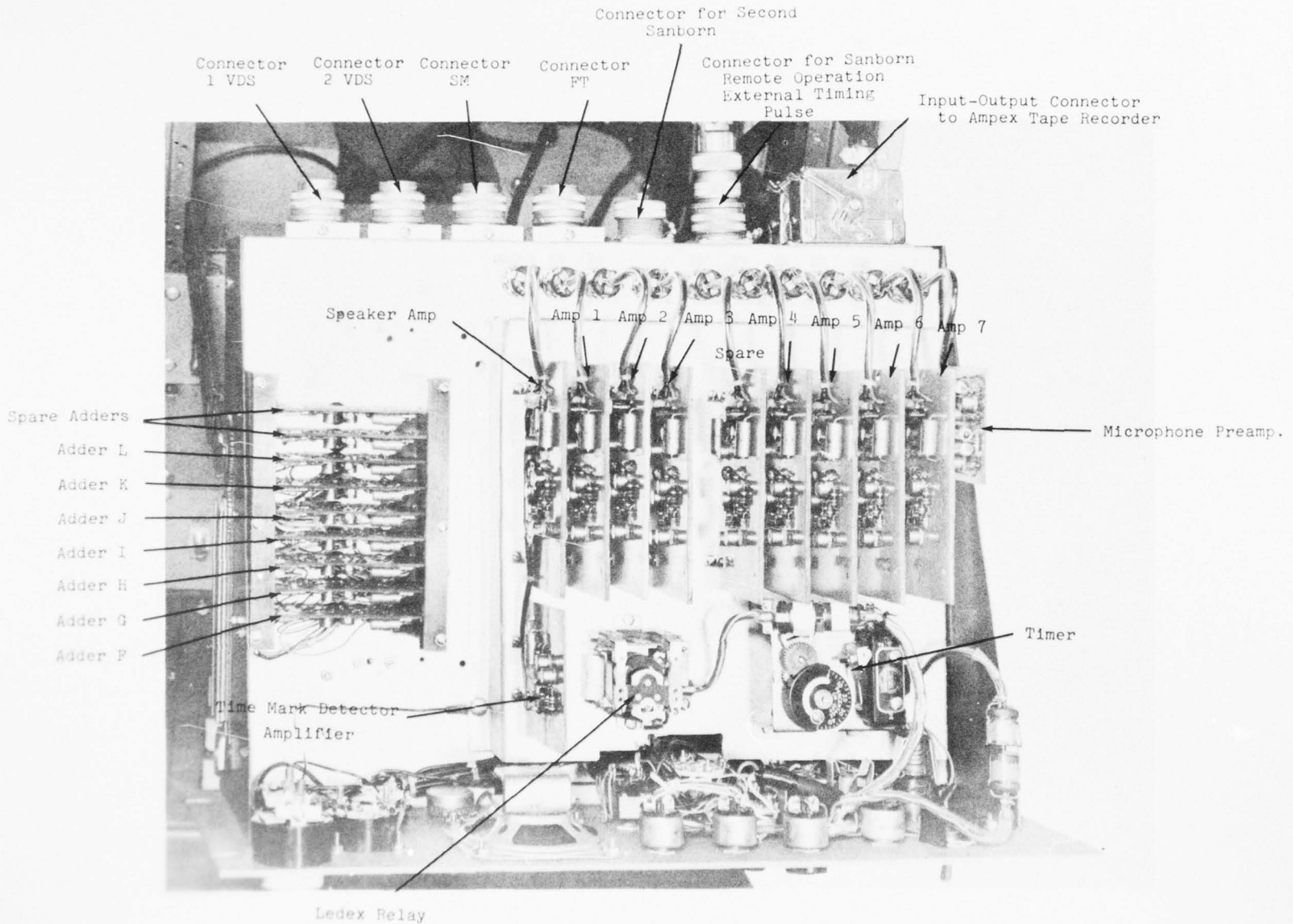
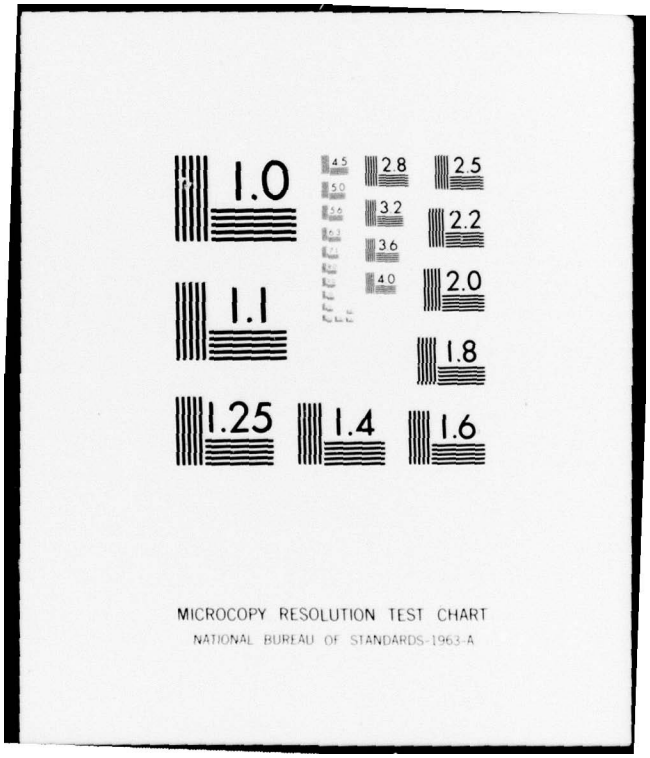

Connector for Second Sanborn
Connector 1 VDS
Connector 2 VDS
Connector SM
Connector FT
Connector for Sanborn Remote Operation External Timing Pulse
Input-Output Connector to Ampex Tape Recorder
Speaker Amp
Amp 1
Amp 2
Amp 3
Amp 4
Amp 5
Amp 6
Amp 7
Spare
Spare Adders
Adder L
Adder K
Adder J
Adder I
Adder H
Adder G
Adder F
Microphone Preamp.
Timer
Time Mark Detector Amplifier
Ledex Relay

FIGURE C.9

AD-A036 314 TRACOR INC ROCKVILLE MD F/G 17/1
TOWED BODY MOTION MEASURMENT SYSTEM INSTRUCTION MANUAL.(U)
JUN 66 NOBSR-91254
UNCLASSIFIED NL

2 OF 2
AD A036314

END
DATE FILMED
3-77


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

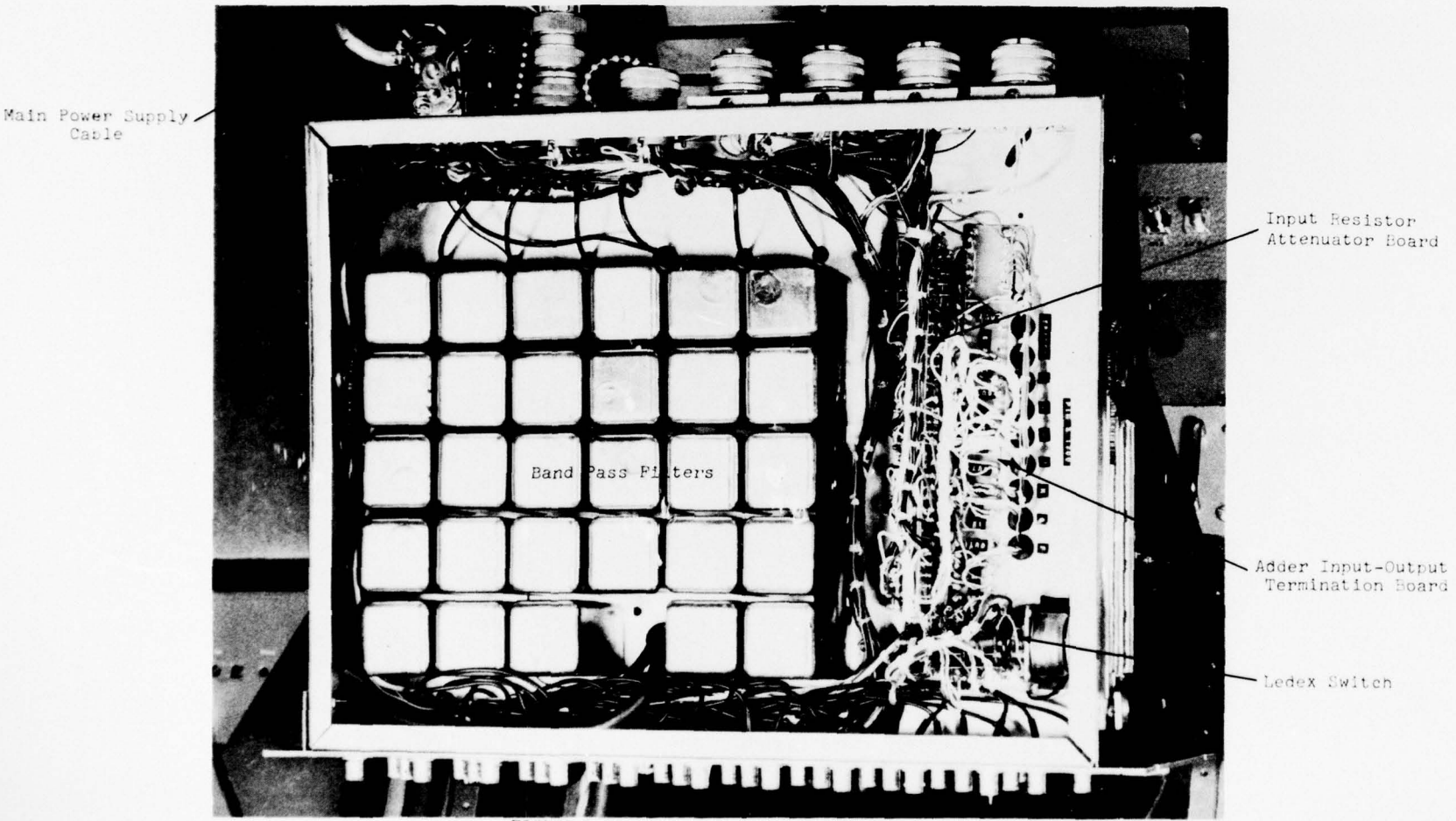


FIGURE C.10

CENTRAL ELECTRONICS PACKAGE: BOTTOM

Cable

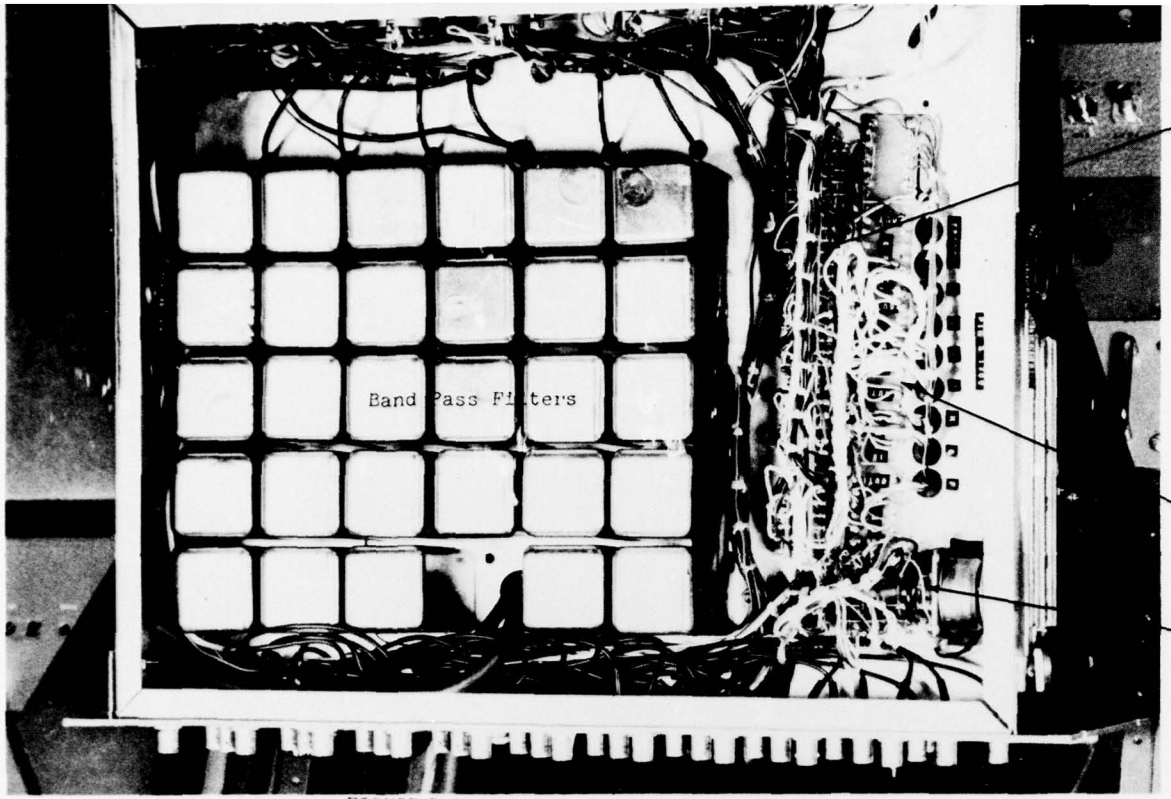


FIGURE C.10

CENTRAL ELECTRONICS PACKAGE: BOTTOM